大黄鱼 Lcnkl3 基因的分子结构、表达特征及多肽片段抗菌活性

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> 摘要:作为重要的免疫基因, NK-lysin参与了鱼类非特异性免疫系统对抗病原感染的免疫应答过程。在 之前的研究中,我们已经发现重要经济鱼类大黄鱼(Larimichthys crocea)体内存在 2 种类型的 NK-lysin 基因。在本文中我们报道了 1 种新型大黄鱼 NK-lysin 基因 Lcnkl3,并对基因序列、表达特征及其多肽 片段的抗菌活性进行了分析。Lcnkl3 基因的开放阅读框长度为 435 bp,编码 144 个氨基酸残基,其多 肽序列 Lcnkl3 中包含 Saposin B 结构域及 6 个高度保守的半胱氨酸残基。系统进化分析表明 Lcnkl3 与 大黄鱼 Lcnkl2 最为相似,与其他鱼类 NK-lysin 多肽则差异较大。Lcnkl3 基因在未受感染的大黄鱼各组 织中具有不同的基础表达量,表达水平最高的组织为心脏。在病原诱导的免疫应答过程中,Lcnkl3 基因 在各组织不同感染阶段的表达模式存在差异。源于 Lcnkl3 成熟肽序列的多肽片段对不同细菌的抑制和 杀灭效果差异显著。以上结果表明 Lcnkl3 属于大黄鱼 NK-lysin 基因家族,并参与了大黄鱼对抗病原感 染的免疫过程。

关键词: NK-lysin 基因; 大黄鱼(Larimichthys crocea); 非特异性免疫系统; 抗菌活性
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NK-lysin 是由毒性 T 细胞(cytotoxic T lymphocytes)和自然杀伤细胞(natural killer cells)产生的小分 子多肽,属于鞘脂激活蛋白样蛋白(saposin-like protein)家族成员^[1-2],在鱼类免疫系统对抗病原感染的 过程中发挥着重要作用^[3]。NK-lysin 的多肽序列中具 有鞘脂激活蛋白 B(Saposin B)结构域及6个半胱氨酸 残基^[4],该特征在鱼类到哺乳动物 NK-lysin 序列中 高度保守。NK-lysin 具备广谱的抗病原活性,不仅能 够杀灭细菌、真菌、病毒、原生动物以及寄生虫^[5-9], 还能抑制肿瘤细胞生长^[10-11],因此具备良好的应用 前景。目前在脊椎动物体内已发现了多种类型的 *NK-lysin* 基因,围绕其结构与免疫活性的研究也不 断增加。

NK-lysin 最初被发现于猪(Sus scrofa)的小肠组 织^[1, 12],随后在脊椎动物体内陆续有 NK-lysin 基因得 到鉴定。在硬骨鱼类中, NK-lysin 基因最先由 Wang 等 发现于斑点叉尾鮰(Ictalurus punctatus)体内^[13-14],随后 其他鱼类中的 NK-lysin 基因也相继得到分析,特别是 近几年在鱼类中发现的 NK-lysin 基因数量增长迅速。 除斑点叉尾鮰外,其他已被发现具有 NK-lysin 基因的 鱼类有: 牙鲆(Paralichthys olivaceus)^[15]、半滑舌鳎 (Cynoglossus semilaevis)^[16]、斑马鱼(Danio rerio)^[17]、团 头鲂(Megalobrama amblycephala)^[18]、草鱼(Ctenopharyngodon idella)^[19]、鲤鱼(Cyprinus carpio)^[20]、罗非鱼 (Oreochromis niloticus)^[21]、大菱鲆(Scophthalmus maximus)^[22]、达氏鲟(Acipenser dabryanus)^[23]、褐菖鲉(Sebastiscus marmoratus)^[24]、大西洋鲑(Salmo salar)^[25-26]、弹 涂鱼(Boleophthalmus pectinirostris)^[27]、巴马拟缨鱼 (Pseudocrossocheilus bamaensis)^[28]、卵形鲳鲹(Trachinotus ovatus)^[29]、黄颡鱼(Pelteobagrus fulvidraco)^[30]、 大西洋鲷(Sparus aurata)^[31]、欧洲海鲈(Dicentrarchus labrax)^[31-32]等。

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大黄鱼(Larimichthys crocea)养殖业在我国水产 养殖业中占据重要地位,但其发展长期受养殖病害问 题制约,而不断深化对大黄鱼免疫功能基因的了解则 可为制定并优化具有针对性的病害防控策略提供支 持。在前期的研究中,我们在大黄鱼组织中发现了 2 种 NK-lvsin 基因,对其基因序列结构及表达调控趋势 的分析表明 Lc-nk-lvsin 为典型的硬骨鱼类 NK-lvsin 成 员^[33], 而 Lenkl2 则属于新型的鱼类 NK-lysin 基因^[34]。 在本文中,我们对在大黄鱼组织中发现的第3种 NKlysin 基因——Lcnkl3 进行了研究, 分析了该基因的序 列特征、组织表达特性、诱导表达趋势及其多肽片段 的抗菌活性,通过将其与另外2种大黄鱼 NK-lvsin 基 因进行比较,发现该基因与Lenkl2更为相似。本文围 绕 Lenkl3 基因开展分析研究, 以期增进对于大黄鱼 NK-lysin 基因家族的了解,为后续进一步探索大黄鱼 NK-lysin 的免疫调控机制及其多肽序列组成与抗病原 活性的关系提供参考。

1 材料与方法

1.1 大黄鱼 Lenkl3 基因的克隆与序列分析

实验用鱼购买自福建宁德三都澳大黄鱼养殖区, 暂养两周至其状态稳定并随机分组,随后利用刺激 隐核虫(Cryptocaryon irritans)感染实验组大黄鱼并 采集各组织样品保存,同时采集未感染大黄鱼各组 织样品保存,用于转录组测序以及基因的组织表达 与诱导表达测定,采集方法如前文所述^[33,35]。测序后

利用生物信息学分析方法在大黄鱼肝脏转录组数据 库中筛洗获得了 Lcnkl3 的参考基因序列, 以该序列 为模板克隆验证 Lcnkl3 基因并分析序列结构, 主要 步骤如下: 在未受感染的大黄鱼肝脏组织中提取总 RNA 并立即将其反转录为 cDNA, 通过特异性引物 (Nkl3-F1 与 Nkl3-R1)扩增 Lcnkl3 基因序列。PCR 扩 增程序为: 首先于 94 ℃预变性 5 min, 随后以 94 ℃ 变性 30 s、55 ℃退火 45 s、72 ℃延伸 1 min 为一个 循环, 共进行 30 个循环, 最后于 72 ℃下延伸 10 min。 将 PCR 扩增产物加至浓度为 1%的琼脂糖凝胶 (Biowset)、将凝胶放置于 TBE 电泳缓冲液中分离基 因片段,随后切下包含 Lenkl3 基因片段的凝胶条带 并使用 DNA 回收试剂盒(Tiangen)回收和纯化目的基 因片段。将纯化的 Lenkl3 基因片段与 pMD19-T 载体 (TaKaRa)连接后转入化学感受态细胞(TransGen),使 用 LB 培养基于 37 ℃恒温培养箱中将包含目的基因 片段的菌液培养 8~10 h。随机挑取单个菌落、使用通 用引物扩增验证后送交上海生工生物工程公司测定 重组阳性克隆的基因序列。获得经过验证的 Lcnkl3 基因片段后以该序列片段为模板设计特异性引物, 利用 cDNA 末端快速扩增技术扩增 Lcnkl3 基因片段 的 3'端及 5'端的序列,用于扩增 Lcnkl3 基因 cDNA 3' 端序列的引物的退火温度分别为 59 ℃、57 ℃、59 ℃、 用于扩增 Lcnkl3 基因 cDNA 5′端序列的引物退火温 度为 57 ℃。Lcnkl3 基因克隆步骤所使用的引物序列 见表1。

表1 用于 Lcnkl3 基因克隆与荧光定量 PCR 检测的引物序列

Tab. 1	Primer sequences u	ised for gene	cloning and q	uantitative PCR	detection of Lcnkl3
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引物名称	引物序列(5′→3′)	作用
Nkl3-F1	GCAGTTGTTGTGAAGTCGTGGGA	基因片段克隆
Nk13-R1	TCTTTGCTATGTAGTTGCTCAGTCT	基因片段克隆
Nk13-F31	CATCGCTCTTCTCCTGCTCTCCG	cDNA 3′扩增
Nk13-F32	CCGCAGTTGTTGTGAAGTCGTGG	cDNA 3′扩增
Nk13-F33	GGGCTCCTGTTATGCCTGTCGGT	cDNA 3′扩增
Nkl3-R51	GCCTGCCGCTTTACTTTGGACAC	cDNA 5′扩增
Nkl3-R52	ATGTACCGACAGGCATAACAGGAGC	cDNA 5′扩增
Nkl3-R53	CTTCCTCCTCTTCAGTTTCGTCCTC	cDNA 5′扩增
RA	AAGCAGTGGTATCAACGCAGAGTAC	cDNA 5′扩增
dT-RA	AAGCAGTGGTATCAACGCAGAGTAC(T)30VN	反转录
Nkl3-FL-F	ATCGCTCTTCTCCTGCTCTC	序列拼接验证
Nkl3-FL-R	CCTTCTCAATAAAGCTTTACACGC	序列拼接验证
Nk13-FQ	CGCCTGCAAGAAGGTCACCA	荧光定量 PCR

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引物名称	引物序列(5'→3')	作用
Nk13-RQ	AAATTCTCCGGGAAGATCCGTT	荧光定量 PCR
ActinF	AAGCCAACAGGGAGAAGATGAC	荧光定量 PCR
ActinR	ACGACCAGAGGCATACA	荧光定量 PCR

使用 BioEdit 软件对获得的 Lcnkl3 基因片段进 行拼接,使用 VecScreen(https://www.ncbi.nlm.nih.gov/ tools/vecscreen/)识别 Lcnkl3 基因序列及 pMD19-T 载体序列,使用 BLAST(https://blast.ncbi.nlm.nih. gov/Blast.cgi)程序分析和比较不同基因序列的相似 性,开放阅读框位置及其编码的多肽序列利用 ORFfinder(https://www.ncbi.nlm.nih.gov/orffinder)进 行预测,使用 SignalP 预测 LcNkl3 多肽的信号肽区 域,利用 PSIPRED (http://bioinf.cs.ucl.ac.uk/psipred/) 和 SMART(http://smart.embl.de/) 预测 LcNkl3 多肽 的二级结构,利用 Clustal Omega(https://www.ebi.ac. uk/Tools/msa/clustalo/)比对不同 NK-lysin 多肽序列的 相似性,利用 MEGA-X 进行系统进化分析,计算 方法使用邻接法(Neighbor-Joining, NJ)。本文中用 于多肽序列比对以及系统进化分析的物种名称见 表 2。

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表 2 用于同源性比对和系统进化分析的鱼类 NK-lysin 多肽序列登录号及参考文献 Tab. 2 Accession numbers of the teleost NK-lysin polypeptide sequences used for the homology and phylogenetic analyses

物种及序列名称	GenBank 登录号	参考文献
大黄鱼 Larimichthys crocea Lc-Nk-lysin	KJ865299	[33]
大黄鱼 Larimichthys crocea Lcnkl2	KP301138	[34]
大黄鱼 Larimichthys crocea Lcnkl3	KP301139	[本文]
斑点叉尾鮰 Ictalurus punctatus type1	NM_001200208	[14]
斑点叉尾鮰 Ictalurus punctatus type2	DQ153186	[14]
斑点叉尾鮰 Ictalurus punctatus type3	DQ153187	[14]
斑马鱼 Danio rerio Nkla	KP100115	[17]
斑马鱼 Danio rerio Nklb	KP100116	[17]
斑马鱼 Danio rerio Nklc	KP100117	[17]
斑马鱼 Danio rerio Nkld	KP100118	[17]
大西洋鲑 Salmo salar Nk-lysin-1	NM_001141110	[25]
大西洋鲑 Salmo salar Nk-lysin-2	EG932844	[25]
大西洋鲑 Salmo salar Nk-lysin-3	EG810337	[25]
大西洋鲑 Salmo salar Nk-lysin-4	EG819316	[25]
巴马拟缨鱼 Pseudocrossocheilus bamaensis Nkla	MH910093	[28]
巴马拟缨鱼 Pseudocrossocheilus bamaensis Nklb	MH916607	[28]
巴马拟缨鱼 Pseudocrossocheilus bamaensis Nklc	MH916605	[28]
巴马拟缨鱼 Pseudocrossocheilus bamaensis Nkld	MK263337	[28]
巴马拟缨鱼 Pseudocrossocheilus bamaensis Nkle	MH916606	[28]
鲤鱼 Cyprinus carpio Nkl1	XM_019120973	[20]
鲤鱼 Cyprinus carpio Nkl2	KX034213	[20]
鲤鱼 Cyprinus carpio Nkl3	XM_019071085	[20]
鲤鱼 Cyprinus carpio Nkl4	XM_019092430	[20]

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		续表
物种及序列名称	GenBank 登录号	参考文献
鲤鱼 Cyprinus carpio Nk15	XP_018952410.1	[20]
鲤鱼 Cyprinus carpio Nkl6	XP_018970060	[20]
团头鲂 Megalobrama amblycephala Nkla	/	[18]
团头鲂 Megalobrama amblycephala Nklb	/	[18]
牙鲆 Paralichthys olivaceus	AU260449	[15]
半滑舌鳎 Cynoglossus semilaevis	KC346974	[16]
草鱼 Ctenopharyngodon idella	KT877168	[19]
罗非鱼 Oreochromis niloticus	MF67882	[21]
大菱鲆 Scophthalmus maximus	KU705506	[22]
卵形鲳鲹 Trachinotus ovatus	MN648454	[29]
弾涂鱼 Boleophthalmus pectinirostris	XM_020919797	[27]
褐菖鲉 Sebastiscus marmoratus	MK913633	[24]
黄颡鱼 Pelteobagrus fulvidraco	MN131138	[30]
欧洲海鲈 Dicentrarchus labrax	ASD56696	[32]
大西洋鲷 Sparus aurata	MN240490	[31]
达氏鲟 Acipenser dabryanus	AZL56981	[23]

1.2 Lcnkl3 基因的组织表达与诱导表达

在组织表达测定实验中,采集3尾未感染大黄鱼 的皮肤、鳃、头肾、脑、心脏、肝脏、脾脏、胃、肠、 肌肉等 10 种组织, 分别在上述组织中提取总 RNA 并 立即反转录为 cDNA, 利用 β -actin 作为内参基因, 设 计特异性引物用于检测 Lcnkl3 基因在未感染大黄鱼 上述 10 种组织中的表达情况,以肝脏组织中 Lcnkl3 基因的表达量为基准,计算不同组织中 Lcnkl3 基因 的基础表达量。随后,分别以大黄鱼受病原感染 6h、 24 h、48 h、72 h、96 h、120 h、144 h 的鳃、头肾、 脾脏和肝脏为模板提取总 RNA 并立即将其反转录为 cDNA,利用 β-actin 作为内参基因,以未感染大黄鱼 相应组织中基因的表达量为基准,测定 Lcnkl3 基因在 大黄鱼 4 种组织中的诱导表达情况。使用 ABI 7500-FAST 荧光定量 PCR 仪进行基因表达量的测定, 根据使用说明书设定扩增程序为: 95 ℃预变性 30 s, 之后以 95 ℃ 5 s、55 ℃ 30 s、72 ℃ 30 s 为一个扩增 循环,共进行40次循环。反应设置空白对照及3个平 行对照, 通过标准曲线评估特异性引物与内参基因引 物的扩增效率, 通过熔解曲线检验扩增的特异性, 使 用 SPSS 21 软件中的单因素方差分析以及 2-^^Ct 方法 对获得的数据进行计算,显著性水平设定为 P 值 <0.05, 数据以平均值±标准误表示。荧光定量 PCR 检测所使用的引物序列见表 1。

1.3 Lenkl3 多肽片段合成与抗菌活性测定

通过分析已有的鱼类 NK-lysin 多肽序列特征, 选取了一段位于 Lenkl3 成熟肽区域的序列片段 (VCNGFRSRFVRSACKKVTRRYQYR),由苏州强耀生 物科技有限公司利用化学方法合成。经过高效液相色 谱仪分离纯化和质谱检测,将以干粉形态保存的 Lenkl3 多肽片段溶解于超纯水中,并通过 2 倍稀释法将多肽 溶液稀释为不同浓度(3 μmol/L, 6 μmol/L, 12 μmol/L, 24 μmol/L, 48 μmol/L, 96 μmol/L, 192 μmol/L)用于后续 实验。

测定了不同浓度的 Lenkl3 多肽溶液对于常见 的革兰氏阳性细菌及革兰氏阴性细菌的抑制与杀 灭效果,所用细菌为金黄色葡萄球菌(Staphylococcus aureus)、大肠杆菌(Escherichia coli)、哈维氏弧 菌(Vibrio harveyi)、副溶血弧菌(Vibrio Parahaemolyticus)、嗜水气单胞菌(Aeromonas hydrophila)和美 人鱼发光杆菌(Photobacterium damselae),实验细菌 菌株由集美大学水产学院赠予并于本实验室保存。 测定前,将保存于-80℃环境中的菌株复苏、活化并 培养至对数期,其中金黄色葡萄球菌和大肠杆菌放 置于 37 ℃环境中培养,其他菌株放置于 28 ℃环境 中培养。多肽片段的抗菌实验步骤参照文献中方法 操作^[33, 36],主要步骤如下:使用浓度为 10 mmol/L 的磷酸钠缓冲液洗脱经活化的细菌菌落并将其吸 光度值稀释调节至 0.001 8,将菌液与不同浓度的多 肽溶液等体积混匀后转入 96 孔板,空白对照组中 使用无菌超纯水代替不同浓度的多肽溶液与细菌 悬浮液等体积混合,阴性对照组中使用 3 μmol/L 的 多肽溶液与无菌的液体培养基等体积混合,各浓度 均设置 3 次平行对照实验。将 96 孔板放置于 37 ℃ 或 28 ℃环境中培养 24 h并记录不同浓度多肽溶液 对细菌的抑制作用,之后再将 96 孔板中的悬浮液 吸出并均匀涂布于固体培养基继续培养 12 h,记录 各浓度多肽溶液对细菌的杀灭作用,抗菌活性实验 进行 3 次重复测定。 框区域的大黄鱼 Lcnkl3 基因序列(图 1)。Lcnkl3 基因 序列全长 604 bp,其中 5'非翻译区长度 27 bp,开放 阅读框区域长度 435 bp,3'非翻译区长度 142 bp。开 放阅读框区域能够编码由 144 个氨基酸残基组成的 多肽序列,多肽序列具有信号肽区域和 Saposin B 结 构域。预测的信号肽切割位点位于第 21 与第 22 个 氨基酸残基(VKS-WE)之间,Saposin B 结构域起始于 第 63 个氨基酸残基,终止于第 139 个氨基酸残基。 Lcnkl3 基因已提交至 GenBank 数据库,登录号为 KP301139。Lcnkl3 多肽的 6 个半胱氨酸残基分别位 于序列的第 65,68,96,108,133,139 位,与其他鱼类 NK-lysin 多肽序列的多重比对结果显示 6 个半胱氨 酸残基在不同鱼类物种间高度保守(图 2)。系统进化 分析表明,Lcnkl3 与 Lcnkl2 最先聚为一类,而与其他 鱼类 NK-lysin 序列的相似程度则较低(图 3)。

2.2 Lcnkl3 基因的组织表达及诱导表达特征

2 结果

2.1 Lcnkl3 基因序列特征

通过基因克隆,获得了一段包含完整开放阅读

Lcnkl3 基因在未受感染的大黄鱼 10 种组织中的 表达量差异较为明显,其表达量最高的组织为心脏, 其次为脾脏、头肾、鳃。肝脏与肌肉中也检测到 Lcnkl3

1	gta	cct	ttg	ctg	act	gaa	aaa	ctg	aga	ATG	ACC	ATG	AGT	'CCT	GCC	ATC	AGC	ATC
1										М	Т	М	S	Ρ	А	Ι	S	I
55	GCT	СТТ	стс	CTG	стс	тсс	GCA	GTT	GTT	GТG	AAG'	TCG	TGG	GAG	тсс	ccc	GAG	GAC
10	Δ	т.	T.	Τ.	T.	q	Δ	V	V	V	K	g	W	F	g	P	F	D
10	11	ш	ш		ш	0	17	v	v	v	T/	0			D	T		D
100	CDD		~~~~	~ ~ ~ ~	~~~	~~~~	~~~~	ית הי ^ר	рст			~ n ~r	nme.		<u>י</u> א דור	77.07	A TH C 7	
109	GAA	ACIO	JAA	JDAG	JAG	JAAG	JAC	JAI	ICI	CAU		JAG.	TIG	AAC	JAIC	JACI	AI GE	AAG
28	巴	T	E	뇬	뜨	E	D	D	5	5	А	뇬	Ц	IN	н	D	М	ĸ
1.60																		
163	GAG	AGA	GCT(GAC	CAT	GAT(GCA	GAG	GAG.	ATA	CTG	CAG	GAT(CAA	GCT'.	TCC	CGG	JGC
46	Е	R	Α	D	Η	D	А	Е	Ε	Ι	L	Q	D	Q	А	F	Ρ	G
217	TCC	[GT]	rat(GCC:	[GT	CGG	FAC	ATT	GTG	LCC5	AAA	GTAZ	AAG	CGG	CAG	GCA	GGCZ	AGA
64	S	<u>C</u>	Y	А	<u>C</u>	R	Y	I	V	S	K	V	K	R	Q	Α	G	R
271	GAT	CAC	FCA.	AAG	GCA	AGA	ATC	CGA	rgt(CTG	ATGA	ATGO	GGA	GTC	rgc <i>i</i>	AATO	GC1	$\Gamma T T$
82	D	Η	S	K	А	R	Ι	R	С	L	М	М	G	V	С	Ν	G	F
325	CGA'	rct <i>i</i>	AGA'	TTC	GTC	AGA	rcco	GCC	rgc)	AAG	AAG	GTC2	ACC	AGG	AGG	CAC	CAAT	ГАС
100	R	S	R	F	V	R	S	А	С	K	K	V	Т	R	R	Y	0	Y
									-									
379	AGA	CTG	AGC	AAC	rac <i>i</i>	ATA	GCA	AAG	AAC	GGA'	ICT:	rcco	CGG	AGAZ	ATT	rgco	GCTZ	AGA
118	R	L	S	N	Y	Т	A	K	N	G	S	S	R	R	Т	С	A	R
																-		
433	CTT	CGT	TTC	TGC	AGG	AGA	300	гст	CAG	таа	ato	ata	cat	ata	ata	cat	ctc	tac
136	T.	P	T.	C	P	P	17	c c	0110	*	acc	aca	out	aca	acy	cuc	000	ege
150	1	11	-11	×		1	•	0	×									
487	222	202	703	aad		aat	~+ ~		at a	a a tu	~+++	- ~ -	a c t /	~+++	+ a+ a	x+ _+	++ at	- c+
407	aaa	acay	yca	aaci	Laad	ayıı	yca	Juan	yıa	Jac	yıı	Jyad	acti		LULY	JUC	Jugi	
541	+ ~+		++ a	a++.	a+ a	+		aat	++ -	~ ~ ~								
541	ιyι	LLL	LLC		LLC	aal	aad	get	LLC	.caC	.yca	aad	add	aad	aad	aad	aad	add
505				_														
393	aaa	aaaa	aaa	a														

图 1 大黄鱼 Lcnkl3 基因的 cDNA 及其编码的多肽序列

Fig. 1 cDNA and the encoded polypeptide sequence of L. crocea Lcnkl3

注:开放阅读框区域以及预测的多肽序列以大写字母表示,非翻译区以小写字母表示,转录起始位点 ATG、终止位点 TAA、6个半胱氨酸残基 及多腺苷酸化终止信号 aataaa 通过下划线标出,信号肽区域及 Saposin B 区域以阴影标出。

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大黄鱼 Larimichthys crocea (Lc-Nk-lysin)	MNSSSVLFVCILGACSVWIVHGRNLKVNDDDQEGAELDISVEAR.KLPGLCWVCKWSLNKVKKLLGRNTTA	70
大黄鱼 Larimichthys crocea (LcNKL2)	MNPAISITLLLLSATVVKSWGSLEGQTEEEED.SSSQLNHDMRERAAHHTEKDEAFPGSCTACKSIVSKVKKHLGKENTK	79
大黄鱼 Larimichthys crocea (LcNKL3)	MIMSPAISIALLLLSAVVVKSWESPEDETEEEEDDSSAELNHDMKERADHDAEEILQDQAFPGSCYACRYIVSKVKRQAGRDHSK	85
斑点叉尾鮰 Ictalurus punctatus (type1)	MFWNLLVASFFIGSACAMHMEYLRVDSAEELLDGSLDSTDEDEDLAMSETQLLPGACWACQWAMKKVKKQLGNNPTV	77
斑点叉尾鮰 Ictalurus punctatus (type2)	\dots	77
斑点叉尾鮰 Ictalurus punctatus (type3)	MLRNLLVASFLIGAAYAVHLEYLKVDS.EELLDETWDEDLLMPEEQI.PGLCWICKRLMKKVKKHLGNHENA	70
羝马鱼 <i>Danio rerio</i> (nkla)	MLRNIFLVGLLIYAVSAAHWEVREVDSAEDELEETPNDNMVKQKFPGMCSLCKYVMKHVKERISADSTP	69
斑马鱼 Danio rerio (nklb)	MLRNIFLVSLLIYAVSAAHWEVREVDSAEDELEETPEDNMVKQKFPGKCTICKYIMNQVKKRLSTKSTP	69
粧马鱼 Danio rerio (nklc)	MLRGIVLLTLLISSACAAHLEMHKEPFPEFDFEGSGEIPKEQL.PGLCWACKWAMGKLRQHISNTANK	67
斑马鱼 Danio rerio (nkld)	MLRGIILLTLLISSVCAVQWEMHKEQHSGIELEGSGEIPTEQL.PCMCWACKWALGKVKRKISNGATQ	67
大西洋鲑 Salmo salar (SsNK-lysin-1)	MKTSLVLLALSLLACSVWEIQGQCREDDQEAQSEKCMEETLFGTCWVCKWALKKVKESTSTSDSQ	65
大西洋鲑 Salmo salar (SsNK-lysin-2)	MKTSLVLLALSLLACSVWEIHGQCQDDQEVVEAQLEKRMQKQLKWICGPCKRALKKVKESISTSSSQ	67
大西洋鲑 Salmo salar (SsNK-lysin-3)	MKTSLVLLALSLLACSVWEIHGQCQDDQEVVEAQLKKRMQQQLKGACKACEWALKKVKKSISTSSRQ	67
大西洋鲑 Salmo salar (SsNK-lysin-4)	MKTSLVLLTLSLLACSVWEVCGQCQEVNLDDQEDPKVVEAQPEKHMVQQLKGTCWACMWALKKVKEHISSSSSV	74
巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla)	MLRNIFLVSLFAYAVCAAHLEIREVDSAEDQDEDIHADGMMKQQIFSKCTICKKIMKMVKKKISPNSTP	69
巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb)	MLRNIFLVSLLVYAVCAAHWEIREVGSAEDODOEISADGMPKQQMSIKCDICKRIMKEVKKKISANPTP	69
巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklc)	.MLRSIVLITLLISTVCALHWEMHKEESTGNELEESSGEIPTEOI.PGVCWACKWAMKKLKRRLSNGATP	68
巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkld)	MLRSIVLIALLISTVGALHWEMHK.ETTGNELOESSGEVOTEOK.PGMCWACKWAMKKLKKOISNGATP	67
巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkle)	MGISQRFGYLNPVRELELSYHDKATENKQMIYCDACKAILRRVIKYIGKTASK	53
理鱼 Cyprinus carpio (Nkl1)	MLRNIFLVSILVYAVCAAHWEIREVDSAEDODEEISADGMPKOOIFNKCDICKKIMKAVKKKLPPNATP	69
理鱼 Cyprinus carpio (Nkl2)	.MLRRIVLITLLISSVCALHLEMRKEESTGNEFEESSGEIETEOL.PGKCWACKWVMRKLKKOISNGATP	68
理鱼 Cyprinus carpio (Nk13)	.MLOSIILISLLISSVCALHWEMOKEDSTGNELEKGSGEIOTEOO.PGICKVCKLAMKKLKKOISNGATL	68
理鱼 Cyprinus carpio (Nkl4)	MIWKIILITLLIFSACAOHWEMHKEESIGNELEESSGEIOTEOI.PGLCWACKWAMGKLKKOISNGTTA	68
理鱼 Cyprinus carnio (Nk15)	.MLRSIILITLLISSVCGLHLEKHKAKSIGNELKEDSVEMPSEOL.PGLCWACKWAMGKLKSEITKGSTK	68
運鱼 Cyprinus carpio (Nk16)	MGMSOHEDHENEVBEMEESYHDKATENKO. MIICGVCKTILBKVITFIGKTASK	53
和头鲂 Megalobrama amblycephala (nkla)	MIRSTILVTLISSVCAFHWEMHKEESNENETEE	68
引头鲂 Megalobrama amblycephala (nklb)	MI. RNVFLVSLI, LYAVCAAHWEI REVDSAEDELEE, TLAD. MT. EOOI FDKCAICKY IMKKVKKRI PSNATP	68
无 <i>評 Paralichthys olivaceus</i>	MGTSSTLLICTIVICSVWTVKGRCFETETDDOE PVDVEPSVEAG, KLEGK WACEWAINKVKRTIGRNATA	70
半滑舌鳎 Cynoglossus semilaevis	MNKSPILLECILAACSVMSVHGKSOEMNIDDEE PAEVELPVEA KPPGLOWG KWAINKVKKAMTOKETY	69
当角 Ctenopharvngodon idella	MLPCTLLATLLISSVCAFTMEMHECNETEDELEO ISGEMAP ACOL PGLWACKWAMCKVKGLISSTATP	69
要主角 Oreochromis niloticus	MEMORY AND A A A A A A A A A A A A A A A A A A	67
大蒸餅 Scophthalmus maximus	METSSVI I VCTI VTCSVMTVHCRSLETNIDDOE OVIVATSVEAG KI PCKOMACKWALNKVKKVMCPNVTS	70
和形 組 餘 Trachinotus ovatus		70
前分组号 International overlas	MIDDSSTUDICTILSCSWIMVOCKC VALIDADOO NONKAFYSFE KI DCVCMACKWAINNVKKTICNNATA	67
型体 Sabastiscus marmoratus		70
電画 Sebustiseus marmoratus	MILIOILIOILIOTALOS MILIOIVILIO ALTO ANTI ANTI ALTO ANTI ANTI ALTO ANTI	82
资源运行 encodignus fill viandeo		68
大而洋鋼 Sparus gurata		70
大田行詞 Sparas and abayanus		64
大黄舟 I arimichthys crocza (I c-Nk-lysin)		147
大黄鱼 Larimichthys crocea (Le-Nk-lysin) 大黄鱼 Larimichthys crocea (LeNKL2) 大黄色 Larimichthys crocea (LeNKL3)	ESVKEKIMRVCNEIG., LLKSLCKKFVKGHLGELIEELITSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFIRSICEKLVKKYQOKLINVIADKGTPESICIRLSLCKSRGQ	147 138 144
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (LcNKL2) 大黄鱼 Larimichthys crocea (LcNKL3) 新貞叉尾綱 Ictalurus nunctatus (type1)	ESVKEKIMRVCNEIGLLKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRTIRSICEKIVRKYQDKLINVIADKGPPESICIRLSLCSRCQ. ARIRCIMGVCNGFRSRFVRSACKKVTRRYQYLSNYIAKNGSSRRICARLRLCRVSQ. DIIKACNKVUNSIC.FURGICKKMINKYLDTUVEELSTTDDPTTICGNGICK.SISMLELFOAFPOHHKOI.	147 138 144 148
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (LcNKL2) 大黄鱼 Larimichthys crocea (LcNKL3) 延点叉尾鮰 Ictalurus punctatus (type1) 班点叉尾鮰 Ictalurus punctatus (type2)	ESVKEKIMRVCNEIGLLKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFIRSICEKLVRKYQDKLINVIADKGTPESICIRLSLCKSRGQ. ARIRCIMMGVCNGFRSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARIRLGRVSQ. DIKAQLKKVCNSIG.FLRGLCKKMINKYLDTLVEELSTTDDPTTICQNLGICK.SLSMLELFQAFPQHHKQI DMIKAOLAEVCNSIG.FLRGLCKTIINKYLDTLVEELSTTDNPTTICVNIGIC.	147 138 144 148 129
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NkL2) 大黄鱼 Larimichthys crocea (LcNkL3) 私点叉尾鮰 Ictalurus punctatus (type1) 私点叉尾鮰 Ictalurus punctatus (type2) 环点叉尾鮰 Ictalurus punctatus (type3)	ESVKEKIMRVCNEIGLLKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFIRSICEKLVRKYQDKLINVIADKGTPESICIRLSLCKSRGQ. ARIRCIMMGVCNGFRSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRLCRVSQ. DI KAQLKKVCNSIGFLRGLCKKMINKYLDTLVEELSTDDPTTICGNLGIC. DMIKAQLAEVCNSIGFLRGLCKTI INKYLDTLVEELSTDDPTKICNNIGIC. EKIKEKLKRGCDKLPVVKDLCKKWWNKNIDFLVEELSTDDPFKAICAKAGLC.PVDMWELIOAFPONYOKL.	147 138 144 148 129 141
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NkL2) 大黄鱼 Larimichthys crocea (LcNKL3) 紅点叉尾鮰 Ictalurus punctatus (type1) 花点叉尾鮰 Ictalurus punctatus (type2) 花点叉尾鮰 Ictalurus punctatus (type3) 斑马龟 Danio rerio (nkla)	ESVKEKIMRVCNEIG., ILKSLCKKFVKGHLGELIEELITSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFIRSICEKLVRKYQDKLINVIADKGTPESICIRLSLCKSRGQ ARIRCIMGVCNGERSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRRVSQ. DIIKAQLKKVCNSIG.FLRGLCKMINKYLDTLVEELSTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI DMIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTDDPTTICVNIGIC. EKIKEKLKRGCDKLP.VVKDLCKKMVNKNIDFLVEELSTDDPTTICVNIGIC. DEIKNKMNLCEKAW.LILKGCOKFVKTHLHTLIDELMINDGVNTICAKAIVCK.FGPRKEFNFIHDRAVNENEMM.	147 138 144 148 129 141 144
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (LcNKL2) 大黄鱼 Larimichthys crocea (LcNKL3) 私点叉尾鮰 Ictalurus punctatus (type1) 私点叉尾鮰 Ictalurus punctatus (type2) 私点叉尾鮰 Ictalurus punctatus (type3) 斑马鱼 Danio rerio (nkla)	ESVKEKIMRVCNEIGLLKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRTIRSICEKIVRKYQDKLINVIADKGTPESICIRLSLCSRCQ ARIRCIMGVCNGFRSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRLCRVSQ. DIIKAQLKKVNSIG.FLRGLCKKMINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI DMIKAQLAEVCNSIG.FLRGLCKKINKYLDTLVEELSTTDDPTTICGNLGIC. EKIKEKLKRCGDKLP.VVKDLCKKMVNKNIDFLVEELSTDDDPTTICAKAGLCK.PVDMWELIQAFPQNYQKL. DEIKNKLMNLCEKAW.LLKGQCQKFVKTHLHTLIDELMNDDGVNTICAKALVCK.FGPPRKEFNFIHDRAVNENEKM DEIKNKLMNLCKAW.VLKSCCKKFIOKHIHTLIDELMNDDGPNTICTKVHACK.SEPPIKEFIFIHDDAYSKL.	147 138 144 148 129 141 144 141
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NKL2) 大黄鱼 Larimichthys crocea (LcNKL3) 延点叉尾鲷 Ictalurus punctatus (type1) 延点叉尾鲷 Ictalurus punctatus (type2) 延点叉尾鲷 Ictalurus punctatus (type3) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nklc)	ESVKEKIMRVCNEIGLLKSICKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRTIRSICEKIVRKYQDKLINVIADKGPPESICIRLSICSRGQ ARIRCIMMGVCNGFRSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRLCRRVSQ DIIKAQLKKVCNSIG.FLRGLCKKMINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI DMIKAQLAEVCNSIG.FLRGLCKTIINKYLDTLVEELSTTDDPTTICVNIGIC EKIKEKLKRGCDKLP.VVKDLCKKMVNKNIDFLVEELSTTDDPTALCAKAGLCK.PVDMWELIQAFPQNYQKL DEIKNKLMNLCEKAW.ILKGCCKFVKTHLHTLIDELMINDGVNTICAKALVCK.FGPPRKEFNFIHDRAVNENEKM DEIKNNIMNICNKAV.VLKSQCKKFIQKHIHLILDELMINDGVNTICAKALVCK.SEPPIKEFIFIHEQAYSKL EELKNLAQVCDGIG.FLRPLCRWFVKKYMDILTEELSTTDGPPTICSHLHVC.	147 138 144 148 129 141 144 141 119
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNKL3) 延点叉尾鮰 Ictalurus punctatus (type1) 延点叉尾鮰 Ictalurus punctatus (type2) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nklc) 延马鱼 Danio rerio (nklc)	ESVKEKLMRVONEIG., ILKSLCKKFVKGHLGELIEELITSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLPRPFIRSICEKLVRKYQDKLINVIADKGTPESICIRLSLCKSRGQ. ARIRCIMGVCNGFRSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRLCRVSQ. DIIKAQLKKVCNSIG.FLRGLCKTINKYLDTLVEELSTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTDDPTTICVNIGIC. EKIKEKLKRGCDKLP.VVKDLCKKMVNKNIDFLVEELSTDDDPKAICAKAGLCK.PVDMWELIQAFPQNYQKL. DEIKNKLMNLCEKAW.LLKGCQCKVKTHLHTLIDELMINDGVNTICAKALVCK.FGPPRKEFNFIHDRAVMENERM. DEIKNKLMNICNKAV.VLKSQCKKFIQKHIHTLIDELMINDGGPNTICTKVHACK.SEPPIKEFIFIHDQAYSKL EKIKENQCDGIG.FLRFLCRWFVKKYMDVLIEELSTDDPFRICSNLWVC.K	147 138 144 148 129 141 144 141 119 121
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (LcNKL2) 大黄鱼 Larimichthys crocea (LcNKL3) 紙点叉尾鮰 Ictalurus punctatus (type1) 紙点叉尾鮰 Ictalurus punctatus (type2) 紙点叉尾鮰 Ictalurus punctatus (type3) 艇马鱼 Danio rerio (nkla) 艇马鱼 Danio rerio (nklb) 艇马鱼 Danio rerio (nklb) 艇马鱼 Danio rerio (nkld) 大西洋蝉 Salmo salar (SNKK-lysin-1)	ESVKEKIMRVENEIG. ILKSLCKKFVKGHLGELIEELITSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGILAKACNGLRPRFIRSICEKLVRKYQVKLINVIADKGTPESICIRLSLCKSRGQ. DIIKAQLKKVCNSIG.FLRGLCKKVTRRYQYRLSNYIAKNGSSRRICARLRLCRVSQ. DIIKAQLKEVCNSIG.FLRGLCKTINKYLDTLVEELSITDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSITDDPTTICGNLGICK.SLSMLELFQAFPQNYQKL. EKIKEKLKRGCDKLP.VVKDLCKKTWNKNIDFLVEELSITDDPTTICAKAGLCK.PVDMWELIQAFPQNYQKL. DEINKNIMNICEKAW.ILKGCQKFVKTHLHTLDELMINDGVNTICKKVHACK.SEPPIKEFNFIHDRAVNENERM. DEINNIMNICNKAV.VLKSQCKKFIQKHIHTLIDELMINDGSPTICTKVHACK.SEPPIKEFIFIHDPAVS.KL. EEIKNQLAQVCDGIG.FLRFLCRWFVKKYMDLITEELSITDPRFTICSHLHVC. DEIKNKLSVCKVG.FLKSLCRGFVNKYMDVLIEELSITDARTICANISVCK.K.	147 138 144 148 129 141 144 141 119 121 127
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (LcNKL2) 大黄鱼 Larimichthys crocea (LcNKL3) 紙点叉尾鮰 Ictalurus punctatus (type1) 紙点叉尾鮰 Ictalurus punctatus (type2) 紙点叉尾鮰 Ictalurus punctatus (type3) 羅马鱼 Danio rerio (nkla) 羅马鱼 Danio rerio (nklb) 羅马鱼 Danio rerio (nklc) 羅马鱼 Danio rerio (nkld) 太西洋鲢 Salmo salar (SsNK-lysin-1) 大西洋鲢 Salmo salar (SsNK-lysin-2)	ESVKEKIMRVCNEIGLLKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFIRSICEKIVRKYQOKLINVIADKGTPESICIRLSLCKSRQ. ARIRCIMGVCNGFRSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRLCRRVSQ. DIIKAQLKKVCNSIG.FLRGLCKTMINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMIKAQLAEVCNSIG.FLRGLCKTMINKYLDTLVEELSTTDDPTTICGNLGIC. EKIKEKLKRCCDKLP.VVKDLCKKMVNNIDFLVEELSTTDDPTTICAKALVCK.FGPPRKEFNFIHDRAVNENEKM. DEIKNKIMNLCEKAW.ILKGQCKFVKTHLHTLIDELMINDGVNTICAKALVCK.FGPPRKEFNFIHDRAVNENEKM. DEIKNKIMNICKAW.VLKSGCKKFIQKHIHTLIDELMIDDGPNTICTKVHACK.SEPPIKEFIFIHDQAYSKL. EEIKNQLAQVCDGIG.FLRPICRWFVKKYMDILTEELSTTDAPTTICHISUCK.K. EEIKVQLSQVCDQIG.FLKSICRGFVNKYMDVLIEELSTTDAPTTICANLSVCK.K ETIKQKLLSVCGKVG.FLKSMCKGIMKKHLWVLIFELSTTDDDTTICVNIKACK.PKEIL.DLSY.	147 138 144 148 129 141 144 141 119 121 127 129
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNKL3) 私点叉尾鮰 Ictalurus punctatus (type1) 死点叉尾鮰 Ictalurus punctatus (type2) 秘马鱼 Danio rerio (nkla) 秘马鱼 Danio rerio (nklb) 秘马鱼 Danio rerio (nklc) 赵马鱼 Danio rerio (nklc) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-3)	ESVKEKIMRVCNEIGLLKSICKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRTIRSICEKIVRKYQDKLINVIADKGTPESICIRLSLKSRGQ ARIRCIMGVCNGFRSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRLCRVSQ. DIIKAQLKKVCNSIG.FLRGLCKTMINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI DMIKAQLAEVCNSIG.FLRGLCKTMINKYLDTLVEELSTTDDPTTICGNLGIC. EKIKEKLKRGCDKLP.VVKDLCKKMVNKNIDFLVEELSTTDDDFAICAKAGLCK.PVDMMELIQAFPQNYQKL. DEIKNKIMNLCEKAW.LLKGQCKFVKTHLHTLIDELMNDDGPNTICAKALVCK.FGPPRKEFNFIHDRAVNENEKM DEIKNNIMNICNKAV.VLKSQCKKFIQKHIHTLIDELMNDDGPNTICTKVHACK.SEPPIKEFNFIHDRAVNENEKM DEIKNNIMNICNKAV.VLKSQCKKFIQKHIMTLIDELSTTDDPTICSHLHVC. DEIKNKLSVCDQIG.FLKSLCRGFVNKYMDVLIEELSTTDDAFTICSHLHVC. DEIKVQLSQVCDQIG.FLKSLCRGFVNKYMDVLIEELSTDDNATTICANISVCK.K. ETLKQKLLSVCDKVG.FLKSNCKGLMKKHLMVVLDELNTSDCMRAICVKIKACK.PKEIL.DLSY. EEIKQKLLSVCGKLP.IVKSTCEDLVKKHLMVVIDELNTSDCMRAICVKIKACK.PKEVL.DLSY.	147 138 144 148 129 141 144 141 119 121 127 129 129
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNKL3) 延点叉尾鮰 Ictalurus punctatus (type1) 延点叉尾鮰 Ictalurus punctatus (type3) 延马鱼 Danio rerio (nkla) 枢马鱼 Danio rerio (nkla) 赵马鱼 Danio rerio (nkld) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-2) 大西洋鲑 Salmo salar (SsNK-lysin-4)	ESVKEKLMRVCNEIG., ILKSLCKKFVKGHLGELIEELITSDDVRTICVNLKACK.PKELS., ELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFTRSICEKLVRKYQDKLINVIADKGTPESICIRLSLCKSRGQ. ARIRCIAMGVCNGERSRFVRSACKKVTRRYQYRLSNYIAKNGSSPRICARLRLCRRVSQ. DIIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTDDPTTICVNIGIC. EKIKEKLKRGCDKLP.VVKDLCKKMVNKNIDFLVEELSTDDDPKAICAKAGLCK.PVDMWELIQAFPQNYQKL. DEIKNKLMNLCEKAW.LLKGCQCKFVKTHLHTLIDELMINDGVNTICAKALVCK.FCPPREEFNFIHDRAVNENERM. DEIKNKLMNLCRKAW.VLKSQCKKFIQKHIHTLIDELMINDGPNTICTKVHACK.SEPPIKEFIFIHDPAVNENERM. DEIKNLGQVCDQIG.FLRFLCRGFVKKYMDULTEELSTDDPFRTICSHLHVC. DEIKVQLSQVCDQIG.FLKSLCGFVKKYMDVLIEELSTDDAPRTICANISVCK.K. ETLKQKLLSVCDKVG.FLKSMCKGIMKKHLWVLIEELSTSDDVRTICVNIKACK.PKEIL.DLSY. EEIKQKLLSYCGKLP.IVKSTCEDLVKKHLWVVIDFLNTSDGVRAICVKIKACK.PKEVL.DLSY.	147 138 144 148 129 141 144 141 119 121 127 129 129 136
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NkL2) 大黄鱼 Larimichthys crocea (Lc-NkL3) 粧点叉尾鮰 Ictalurus punctatus (type1) 斑点叉尾鮰 Ictalurus punctatus (type2) 斑马鱼 Danio rerio (nkla) 斑马鱼 Danio rerio (nkla) 斑马鱼 Danio rerio (nklb) 斑马鱼 Danio rerio (nklb) 斑马鱼 Danio rerio (nkld) 大西洋蛙 Salmo salar (SsNK-lysin-1) 大西洋蛙 Salmo salar (SsNK-lysin-3) 大西洋蛙 Salmo salar (SsNK-lysin-3)	ESVKEKIMRVENEIG. ILKSLCKKFVKGHLGELIEELITSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGILAKACNGLRPRTRSICEKUVRKYQKLINVIADKGTPESICIRLSLCKSRGQ ARIRCIMGVENGERSRFVRSACKKVTRRYQYRLSNYIANNGSSRRICARLGRRVSQ DIIKAQLAEVENSIG.FLRGLCKTINKYLDTLVEELSTTDPTTICGNLGICK.SLSMLELFQAFPQHHKQI DMIKAQLAEVENSIG.FLRGLCKTINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQNYQKL DEIKNKLMNLCEKAW.ILKGCQKFVKTHLHTLIDELMINDGVNTICAKAIVCK.FGPRKEFNFIHDRAVNENERM DEIKNKLMNLCEKAW.ILKGCQKFVKTHLHTLIDELMINDGVNTICAKAIVCK.FGPRKEFNFIHDRAVNENERM DEIKNKLMNLCEKAW.ILKGCQKFVKTHLHTLIDELMINDGPTICTKVHACK.SEPPIKEFIFIHDRAVNENERM DEIKNKLSVDKVG.FLKSLCRGFVNKYMDUITEELSTTDAPRTICSHLHVC. DEIKNKLSVCDKVG.FLKSLCRGFVNKYMDUITEELSTDORTICSHLHVC. EEILKQLLSVCDKVG.FLKSLCRGFVNKHLMVLIEELSTDORTICVNIKACK.PKEIL.DLSY. EEIKQKLLSVCGKLP.IVKSTCEDLVKKHLMVVIDFINTSDCMRAICVKIKACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.IVKSTCEDLVKKHLMVVIDELNTSDCMRAICVKIKACK.PKEVL.DLSY. EEIKQKLLSVCGKMVG.FLKSLCKGVKKHLMVVLVEELSTSDDVRTICVNIKACK.PKEVL.DLSY. EEIKQKLLSVCGKMVG.FLKSLCKGVKKHLMVVLVEELSTSDDVRTICVNIKACK.PKEVL.DLSY. EEIKQKLLSVCGKMVG.FLKSLCKGVKKHLMVVLVEELSTSDDVRTICVNIKACK.PKEVL.DLSY.	147 138 144 148 129 141 144 141 121 127 129 129 136 141
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NkL2) 大黄鱼 Larimichthys crocea (LcNKL3) 紙点叉尾鮰 Ictalurus punctatus (type1) 私点叉尾鮰 Ictalurus punctatus (type2) 紙点叉尾鮰 Ictalurus punctatus (type3) 艇马鱼 Danio rerio (nkla) 艇马鱼 Danio rerio (nklb) 艇马鱼 Danio rerio (nklc) 艇马鱼 Danio rerio (nkld) 大西洋鲢 Salmo salar (SsNK-lysin-1) 大西洋鲢 Salmo salar (SsNK-lysin-2) 大西洋鲢 Salmo salar (SsNK-lysin-3) 大西洋鲢 Salmo salar (SsNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla)	ESVKEKIMRVCNEIGLLKSICKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFIRSICEKIVRKYQOKLINVIADKGTPESICIRLSICKSRQ. ARIRCIMGVCNGFRSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRICRRVSQ. DIIKAQLKKVCNSIG.FLRGLCKKMINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMIKAQLAEVCNSIG.FLRGLCKKTINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQNYQKL. EKIKEKLKRCCDKLP.VVKDLCKKMVNKNIDFLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQNYQKL. DEIKNKIMNLCEKAW.ILKGQCKFVKTHLHTLIDELMINDGVNTICAKALVCK.FGPPRKEFNFIHDRAVNENEKM. DEIKNNIMNICNKAV.VLKSGCKFVKHLHHLIDELMINDGVNTICTKVHACK.SEPPIKEFIFIHDQAYSKL. EEIKNQLAQVCDGIG.FLRFLCRWFVKKYMDILTEELSTTDGPRTICSHLHVC. DEIKNILMSVCDKVG.FLKSUCRGFVNKYMDVLIEELSTTDDPTTICVNIKACK.PKEIL.DLSY. EEIKQKLLSVCDKVG.FLKSUCRGFVNKHLWVVIDFLNTSDGVRTICVKIKACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.IVKSTCEDLVKKHLWVVIDELNTSDGVRTICVKIKACK.PKEVL.DLSY. DEIKQLLSVCDKVG.ILKSLCKGMVKKHLWVIDELMTSDGVRTICVKIKACK.PKEVL.DLSY. EEIKQKLLSVCDKVG.FLKSUCRGFVKKHLWVVIDELMTSDGVRTICVKIKACK.PKEVL.DLSY. DEIKTKINDTCMKVG.FLKSQCKRFVEKYLGSLIDELMTDDGPNTICIKIKACK.PKEVL.DLSY.	147 138 144 148 129 141 144 141 121 127 129 129 136 141 144
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNKL3) 私点叉尾鮰 Ictalurus punctatus (type1) 私点叉尾鮰 Ictalurus punctatus (type2) 私点叉尾鮰 Ictalurus punctatus (type3) 秘马鱼 Danio rerio (nkla) 秘马鱼 Danio rerio (nkla) 赵马鱼 Danio rerio (nkld) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲢 Salmo salar (SsNK-lysin-4) 旦马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 已马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla)	ESVKEKLMRVCNEIG., ILKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELS., ELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFTRSICEKLVRKYQDKLINVIADKGTPESICIRLSLCKSRGQ. ARIRCIAMGVCNGFRSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRLCRRVSQ. DIIKAQLKKVCNSIG.FLRGLCKMINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. EKIKEKLKRGCDKLP.VVKDLCKKMVNKNIDFLVEELSTTDDPTTICTNIGGC. EKIKEKLKGCDKLP.VVKDLCKKMVNKNIDFLVEELSTDDDPKAICAKAGLCK.PVDMWELIQAFPQNYQKL. DEIKNKLMNLCEKAW.LLKGCCQKFVKTHLHTLIDELMINDGYNTICAKALVCK.FGPPREENFIHDRAVNENERM. DEIKNKLMNLCKAW.VLKSQCKFFIQHIHTLIDELMINDGYNTICAKALVCK.SEPPIKEFIFIHDQAYSKL EEIKNQLAQVCDGIG.FLRPICRWFVKKYMDVLIEELSTTDAPTICANLSVCK.K. ETILKQKLLSVCDKVG.FLKSMCKGIMKHLWVLIEELSTDDARAICVKIKACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.UKSTCEDLVKKHLWVVIDFLNTSDGWRAICVKIKACK.PKEVL.DLSY. EEIKQKLLSVCDKMG.LLKSLCKGPVKKHLWVVUELSTSDDVRTICINIKACK.PKEVL.DLSY. EEIKQKLLSVCDKMG.LLKSLCKGPVKKHLWVVDELMTSDGWRTICINIKACK.PKEVL.DLSY. DLIKKKLNDICKKLPVKHLWVUELSTSDDVRTICINIKACK.PKEVL.DLSY. EEIKQKLLSVCDKMG.LLKSLCKGPVKKHLWVUELSTSDDVRTICINIKACK.PKEVL.DLSY. DEIKYKLNDICKKLSVCDKKHLWVVELSELSTSDDVRTICINIKACK.PKEVL.DLSY. DEIKYKLNDICKKLSVCDKMG.LLKSLCKGPVKKHLWVIDELMTDDGPNICIKKLACK.PKEVL.DLSY. DEIKYKLNDICKKKLSVCDKKRJLQSLIDELMTDDGPNICIKKLACK.PKEVL.DLSY. DEIKYKLNDICKKKLSVCDKKRJLQSLIDELMTDDGPNICIKKLCK.FARTIKFIVHDQAQFINENK.DDIKKKLGSICDEIG.FLKSLCRKFVKYLQSLIDELMTDDGPNICIKKHCK.EARTIKFIVHDQAQFINENK.DDIKKKLGSICDEIG.FLKSLCRKFVKYLDSLIDEMTDDGPNICIKKHCK.EARTIKFIVHDQAQFINENK.DDIKKKLGSICDEIG.FLKSLCRKFVKYLTDTLVEELSTTDDPRNICIKNISKEKK.	$147 \\ 138 \\ 144 \\ 148 \\ 129 \\ 141 \\ 141 \\ 141 \\ 121 \\ 127 \\ 129 \\ 129 \\ 129 \\ 136 \\ 141 \\ 144 \\ 122 \\$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNKL3) 延点叉尾鮰 Ictalurus punctatus (type1) 延点叉尾鮰 Ictalurus punctatus (type3) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nklc) 赵马鱼 Danio rerio (nklc) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-2) 大西洋鲑 Salmo salar (SsNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla)	ESVKEKLMRVCNEIG., ILKSLCKKFVKGHLGELIEELITSDDVRTICVNLKACK.PKELS., ELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFTRSICEKLVRKYQDKLINVIADKGTPESICIRLSLCKSRGQ. ARIRCIAMGVCNGERSRFVRSACKKVTRRYQYRLSNYIAKNGSSPRICARLRLCRRVSQ. DIIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTDDPTTICVNIGIC. EKIKEKLKRGCDKLP.VVKDLCKKMVNKNIDFLVEELSTDDDPKAICAKAGLCK.PVDMWELIQAFPQNYQKL. DEIKNKLMNLCEKAW.LLKGCQCKFVKTHLHTLIDELMINDGVNTICAKALVCK.FCPPREFNFIHDRAVNENERM. DEIKNNLMNLCKAW.VLKSQCKKFIQKHIHTLIDELMINDGVNTICTKVHACK.SEPPIKEFNFIHDRAVNENERM. DEIKNKLSVCDKVG.FLKSUCKGFUKKYMDULTEELSTDDPRTICTKVHACK.SEPPIKEFNFIHDRAVNENERM. EEILKQLLSVCDKVG.FLKSUCKGFUKKHLWVLIEELSTDDPRTICTNLAKSK.KK. EEILKQLLSVCGKUG.FLKSUCKGFUKKHLWVLIEELSTDDVRTICVNIKACK.PKEUL.DLSY. EEILKQKLLSYCGKLP.IVKSTCEDLVKKHLWVVIDFLNTSDGVRTICVKIKACK.PKEVL.DLSY. VEILQKLLSVCGKUG.FLKSUCKGFUKKHLWVVIDELSTSDDVRTICVNIKACK.PKEVL.DLSY. DEIKVKLLSVCGKLP.LVKSTCEDLVKKHLWVVIDELSTSDDVRTICVKIKACK.PKEVL.DLSY. DEIKVKLLSVCGKLP.LKSTCKHVKHLWVIVELSSDDVRTICVKIKACK.PKEVL.DLSY. DEIKTKLNDTCMKVG.PLKRQCKRFVEKYLGSUDELMTDDGPNTICIKIRACK.PEYIL.DLSY. DEIKTKLNNICDKFK.PLKVCKHFVEKYLGSUDELMTDDGPNTICIKIRACK.PEPIKEFIVVRDQAH.DNF. DEIKTKLNNICDKFK.PLKVCKHFVEKYLGSLDELMTDDGPNTICIKIRACK.FARTIKEFIVVHDQAQFINENK. DDIKKKLGSICDEIG.FLKSLCRKFVKYNTDTIVELSSTDDPRTICVNISVCK.K.	$147 \\ 138 \\ 144 \\ 148 \\ 129 \\ 141 \\ 144 \\ 141 \\ 121 \\ 127 \\ 129 \\ 129 \\ 129 \\ 136 \\ 141 \\ 144 \\ 122 \\ 121 \\ 141 \\ 122 \\ 121 \\ 141 \\ 122 \\ 121 \\ 141 \\ 122 \\ 121 \\ 141 \\ 144 \\ 122 \\ 121 \\ 141 \\ 144 \\ 122 \\ 121 \\ 141 \\ 144 \\ 122 \\ 121 \\ 141 \\ 144 \\ 122 \\ 121 \\ 141 \\ 144 \\ 122 \\ 121 \\ 141 \\ 144 \\ 141 \\ 141 \\ 144 \\ 141 \\ 141 \\ 144 \\ 141 $
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NkL2) 大黄鱼 Larimichthys crocea (Lc-NkL3) 紙点叉尾鮰 Ictalurus punctatus (type1) 紙点叉尾鮰 Ictalurus punctatus (type2) 紙点叉尾鮰 Ictalurus punctatus (type3) 紙马鱼 Danio rerio (nkla) 紙马鱼 Danio rerio (nkla) 低马鱼 Danio rerio (nklb) 低马鱼 Danio rerio (nkld) 大西洋蛙 Salmo salar (SsNK-lysin-1) 大西洋蛙 Salmo salar (SsNK-lysin-2) 大西洋蛙 Salmo salar (SsNK-lysin-3) 大西洋蛙 Salmo salar (SsNK-lysin-3) 大西洋蛙 Salmo salar (SsNK-lysin-3) 大西洋蛙 Salmo salar (SsNK-lysin-4) 马利援缰鱼 Pseudocrossocheilus bamaensis (PbNkla) 马利援缰鱼 Pseudocrossocheilus bamaensis (PbNkld) 巴马拟缰鱼 Pseudocrossocheilus bamaensis (PbNkld)	ESVKEKIMRVENEIG. ILKSLCKKFVKGHLGELIEELITSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGILAKACNGLRPRFTRSICELVKYRYQVKLINVIADKGTPESICIRLSLCKSRGQ	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 119\\ 121\\ 127\\ 129\\ 129\\ 136\\ 141\\ 144\\ 122\\ 121\\ 112 \end{array}$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNKL3) 私点又尾麵 Ictalurus punctatus (type1) 私点又尾麵 Ictalurus punctatus (type2) 私点又尾麵 Ictalurus punctatus (type3) 都马鱼 Danio rerio (nkla) 和马鱼 Danio rerio (nklc) 和马鱼 Danio rerio (nklc) 和马鱼 Danio rerio (nklc) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla)	ESVKEKIMRVCNEIG. LLKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELS. ELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFIRSICEKIVRKYQVKLMVIADKGTPESICIRLSLKSRQ. ARIRCIAMGVCNGFRSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRLCRRVSQ. DIIKAQLKKVCNSIG. FLRGLCKTMINKYLDTLVEELSTTDDPTTICGNLGICK.SLSAMELFQAFPQHHKQI. DMIKAQLAEVCNSIG. FLRGLCKTMINKYLDTLVEELSTTDDPTTICGNLGICK.SLSAMELFQAFPQNYQKL. DEIKNKLMNLCEKAW. LLKGQCQKFVKTHLHTLIDELMINDGVNTICAKALVCK.FGPPRKEFNFTHDRAVNENEKM. DEIKNKIMNICOKAW.VLKSQCQKFVKTHLHTLIDELMINDGVNTICAKALVCK.FGPPRKEFNFTHDRAVNENEKM. DEIKNKLMNLCEKAW. LLKGQCQKFVKTHLHTLIDELMINDGVNTICAKALVCK.FGPPRKEFNFTHDRAVNENEKM. DEIKNKLMNLCKAW.VLKSQCKFVCNHLHTLIDELMINDGVNTICAKALVCK.FGPPRKEFNFTHDRAVNENEKM. DEIKNLMNICOKAV.VLKSQCKFVCNHLHVLIEELSTTDGPRTICSHLHVC. DEIKVQLSQVCDQIG.FLKSLCRGFVNKYMDVLIEELSTTDDPTTICVNIKACK.PKEIL.DLSY. EEIKQKLLSVCDQVG.FLKSUCKGIMKKHLMVVIDFLNTSDDVRTICVNIKACK.PKEVL.DLSY. EEIKQKLLSVCDKVG.LLKSSLCKGVVKKHLMVVIDELNTSDDVRTICVNIKACK.PKEVL.DLSY. DEIKTKINDTCMKVG.FLKSUCKGVVKKHLMVVIDELNTSDDVRTICVNIKACK.PKEVL.DLSY. DEIKTKINDTCMKVG.FLKSUCKGVVKKHLMVVIDELNTSDDVRTICVNIKACK.PKEVL.DLSY. DEIKTKINDTCMKVG.FLKSUCKGVVKHLMVVIDELNTDGPNTICVNIKACK.PKEVL.DLSY. DEIKTKINDTCMKVG.FLKSUCKGVVKHLMVVIDELNTDGPNTICVNIKACK.PKEVL.DLSY. DEIKTKINDTCMKVG.FLKSUCKGVVKHLMVVIDELNTDDGPNTICVNIKACK.PKEVL.DLSY. DEIKTKINNICDKK.PLRVQCKHFVEKYLQSLIDELMTDDGPNALCTKIHVK.ERARTIKEFIVVHQAQFINENK. DDIKKKLGSICDEIG.FLKSLCRKFVNKYTDTIVEELSTTDDPTTICVNISVCK.K. EDIKKKLEMVCDEIG.FLKSLCRKFVNKYTDTIVEELSTTDDPTTICVNISVCK.K. DDIKKKLEMVCDEIG.FLKSLCRKFVNKYTDTIVEELSTTDDPTTICVNISVCK.K. DDIKKKLEMVCDEIG.FLKSLCRKFVNKYTDTIVEELSTTDDPTTICVNISVCK.K.	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 119\\ 121\\ 127\\ 129\\ 136\\ 141\\ 144\\ 122\\ 121\\ 112\\ 141\\ \end{array}$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNKL3) 私点叉尾鮰 Ictalurus punctatus (type1) 私点叉尾鮰 Ictalurus punctatus (type2) 私点叉尾鮰 Ictalurus punctatus (type3) 秘马鱼 Danio rerio (nkla) 秘马鱼 Danio rerio (nkla) 赵马道 Danio rerio (nkld) 大西洋蛙 Salmo salar (SsNK-lysin-1) 大西洋蛙 Salmo salar (SsNK-lysin-2) 大西洋蛙 Salmo salar (SsNK-lysin-3) 大西洋蛙 Salmo salar (SsNK-lysin-4) 旦马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla)	ESVKEKLMRVCNEIG., ILKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELS., ELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFIRSICEKLVRKYQDKLINVIADKGTPESICIRLSLCKSRGQ. ARIRCIAMGVCNGFRSRFVRSACKKVTRRYQYRLSNYIAKNGSSPRICARLRLCRRVSQ. DIIKAQLAEVCNSIG.FLRGLCKMINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQNYQKL. EKIKEKLKRGCDKLP.VVKDLCKMVNKNIDFLVEELSTDDDPKAICAKAGLCK.PVDMWELIQAFPQNYQKL. DEIKNKLMNLCEKAW.LLKGCCCKFVCHLHTLIDELMINDGVNTICAKALVCK.FGPPREEFNFIHDRAVNENERM. DEIKNKLMNLCKAW.VLKSQCKKFIQKHIHTLIDELMINDGVNTICAKALVCK.SEPPIKEFIFIHDQAYS.KL. EEIKNQLAQVCDGIG.FLRFLCRVFVKYMDVLIEELSTDDPTICTKVHACK.SEPPIKEFIFIHDQAYS.KL. EEIKQKLLSVCGKF.UKSTCEDLVKKHLWVLDELSTDDPTICVNIKACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.IVKSTCEDLVKKHLWVVIDELMTSDGVRTICVKIKACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.LVKSTCEDLVKKHLWVVIDELMTSDGVRTICVKIKACK.PKEVL.DLSY. DEIKVKLSVCGKLP.LUKSTCEDLVKKHLWVVIDELMTSDGVRTICVKIKACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.LUKSTCEDLVKKHLWVVIDELMTDDGPNTICINIKACK.PKEVL.DLSY. DEIKTKLNNICKKL.PLRVQCKHFVEKYLAGULDEMTDDGPNAICKKIKACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.FIKSTCKFVKYTDTIVEELSTTDDPTTICINIKACK.PKEVL.DLSY. DEIKTKLNNICKK.PLRVQCKHFVEKYLAGULDEIMTDDGPNAICKKIKACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.FIKSCCKFVEKYLAGULDEIMTDDGPNAICTKHVKK.EARTIKEFIVHDQAGFINENK. DEIKTKLNNICKK.PLRVQCKHFVEKYLDYIDTIVEELSTTDDPATICVNISVCK.K. EDIKKKLEMVCDEIG.FIKSLCRFVNQYRDTIVEELSTTDDPTICVNISVCK.K. EDIKKKLEMVCDEIG.FIKSLCRFVNQYRDTIVEELSTTDDPTICVNISVCK.K. DEVNRQLDRICKRIR.IFFNNQYRDTIVEELSTTDDPTICVNISVCK.K. DEVNRQLDRICKRIR.IFFNNQYRDTIVEELSTTDDPTICVNISVCK.K. DEVNRQLDRICKRIR.FIKNVCYDFILVEELSTTDDAKTICVNIGVCK.K. DEVNRQLDRICKRIR.PVSQCKKVVCYLPNIIDELMTEDGPNTICVNISVCK.K. DEVNRQLDRICKRILVNQDEIG.FIKSLCRFVNQYRDTIVEELSTTDDAKTICVNIGVCK.K. DEVNRQLDRICKRILVNCDEIG.FIKSLCRFVNQYRDTIVEELSTTDDAKTICVNIGVCK.K. DEVNRQLDRICKRILVNCDEIG.FIKSLCRKFVNQYRDTIVEELSTTDDAKTICVNIGVCK.K. DEVNRQLDRICKRILVNCDEIG.FIKSLCRKVNQYRDTIVEELSTTDDAKTICVNIGVCK.K.	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 127\\ 129\\ 136\\ 141\\ 144\\ 122\\ 121\\ 112\\ 112\\ 112\\ 121\\ 112\\ 122\\ \end{array}$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NkL2) 大黄鱼 Larimichthys crocea (LcNKL3) 延点叉尾鮰 Ictalurus punctatus (type1) 延点叉尾鮰 Ictalurus punctatus (type2) 延点叉尾鮰 Ictalurus punctatus (type3) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nklb) 达马洋壘 Salmo salar (SSNK-lysin-1) 大西洋鲀 Salmo salar (SSNK-lysin-2) 大西洋鲀 Salmo salar (SSNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb)	ESVKEKLMRVCNEIG. ILKSLCKKFVKGHLGELIEELITSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFTRSICEKLVKKYQDKLINVIADKGTPESICIRLSLCKSRGQ. ARIRCIAMGVCNGERSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRLRRVSQ. DIIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQNYQKL. EKIKEKLKRGCDKLP.VVKDLCKKMVNKNIDFLVEELSTDDDPTTICGNLGICK.SLSMLELFQAFPQNYQKL. DEIKNKLMNLCEKAW.LLKGCQCKFVKTHLHTLIDELMINDGVNTICAKARUCK.FCPPRKEFNFTHDRAVNENERM. DEIKNNLMNLCKAW.VLKSQCKKFIQKHIHTLIDELMINDGVNTICAKARUCK.FCPPRKEFNFTHDRAVNENERM. DEIKNKLMNLCEKAW.LLKGCQCKFVKTHLHTLIDELMINDGVNTICAKARUCK.FCPPRKEFNFTHDRAVNENERM. DEIKNKLMNLCEKAW.LLKSGCQKFVKTHLHTLIDELMINDGSVNTICKVHACK.SEPPIKEFIFTHBQAYS.KL EEIKNQLAQVCDGIG.FLKSLCRGFVNKYMDULIEELSTTDDPRTICSHLHVC. DEIKVKLSVCDKVG.FLKSNCKGLMKKHLWVLIEELSTDDVRTICVNIKACK.PKEIL.DLSY. EEIKQKLLSVCGKUG.LLKSLCKGVVKKHLWVLVEELSTSDDVRTICVNIKACK.PKEVL.DLSY. EEIKQKLLSVCGKUG.LLKSLCKGVVKKHLWVLVEELSTSDDVRTICVNIKACK.PKEVL.DLSY. DEIKTKLNNICDKKK.PLKNCKGLWKHLWVLVEELSTSDDVRTICINIKACK.PKEVL.DLSY. DEIKTKLNNICDKKF.PLKNCKGLWKHLWVLVEELSTSDDVRTICINIKACK.PKEVL.DLSY. DEIKTKLNNICDKKF.PLKNCKGLWKYHTUVVEELSTSDDVRTICINIKACK.PKEVL.DLSY. DEIKTKLNNICDKKF.PLKNCKFFVKYYDTIVEELSTTDDPRTICINISCK.K. DEIKKKLEMVCDEIG.FLKSLCRKFVKKYTDIVEELSTDDPRTICINISCK.K. DEVNRQLDRICKRIR.IRG.CTRFLQKYKNKLVIALLSGDKASTICIKLWCK.SRPPIKEFIVVHDQAGFLNENK. DDIKKKLGMVCDEIG.FLKSLCRKFVNKYTDIVEELSTTDDPRTICINISCK.K. DEVNRQLDRICKRIR.IRG.CTRFLQKYKNKLVIALLSGDKASTICIKLKMCRRMYVQTH. DEIKKKLEMVCDEKK.PKSCKKLVNKLVIALLSGDKASTICIKLKMCRRMYVQTH.DNF. DDIKKKLAMVCDEIG.FLKSLCRKFVNKYNCTUVELSTDDAATICANIGVCK.K. DEVNRQLDRICKRIR.IRG.CTRFLQKYKNKLVIALLSGDKASTICIKLKMCRRMYVQTH.DNF. DDIKKKLAMVCDEIG.FLKSLCRKFVNKYNCTUVEELSTTDDAATICANIGVCK.K. DDIKKKLAMVCDEIG.FLKSLCRKFVNKYNCTUVELSSTDDAATICANIGVCK.K. DDIKKKLAMVCDEIG.FLKSLCRKFVNKYNCTUVELSTDDAATICANIGVCK.K. DDIKKKLAMVCDEIG.FLKSLCRKFVNKYNCTUVELSTDDAATICANIGVCK.K. DDIKKKLAMVCDEIG.FLKSLCRKFVNKYNTUVELSTDDAATICANIGVCK.K.SKPPIKEFILVHDQAHDNF. DDIKKKLAMVCDEIG.SLKSLCRKFVNKYNTIVELSTDDAATICANIGVK.K.	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 121\\ 127\\ 129\\ 136\\ 141\\ 144\\ 122\\ 121\\ 112\\ 141\\ 112\\ 121\\ 141\\ 122\\ 126 \end{array}$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NkL2) 大黄鱼 Larimichthys crocea (LcNKL3) 紙点叉尾鮰 Ictalurus punctatus (type1) 延点叉尾鮰 Ictalurus punctatus (type2) 延点叉尾鮰 Ictalurus punctatus (type3) 涎马鱼 Danio rerio (nkla) 涎马鱼 Danio rerio (nkla) 涎马鱼 Danio rerio (nklb) 延马鱼 Danio rerio (nklb) 无马瑾 Salmo salar (SsNK-lysin-1) 大西洋蛙 Salmo salar (SsNK-lysin-3) 大西洋蛙 Salmo salar (SsNK-lysin-3) 大西洋蛙 Salmo salar (SsNK-lysin-3) 大西洋蛙 Salmo salar (SsNK-lysin-3) 大西洋蛙 Salmo salar (SsNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟 Salar (Sprinus carpio (Nkl3) 樫鱼 Cyprinus carpio (Nkl3)	ESVKEKIMRVENEIG. ILKSLCKKFVKGHLGELIEELITSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGILAKACNGLRPRTRSICEKIVKKGHLGELIEELITSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF ARIRCIMGVENGFRSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRCRRVSQ. DIIKAQLAEVENSIG.FLRGLCKTINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMIKAQLAEVENSIG.FLRGLCKTINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQNYQKL. DEIKNKIMNLCEKAW.ILKGCQKFVKTHLHTLIDELSTTDDPTTICAKALVCK.FGPRKEFNFIHDRAVNENEMM. DEIKNNIMNLCKAW.ILKGCQKFVKTHLHTLIDELMIDGYNTICAKALVCK.FGPRKEFNFIHDRAVNENEMM. DEIKNKIMNLCKAW.ILKGCQKFVKTHLHTLIDELSTTDDPTTICVNLFACK.SEPPIKEFIFIHDRAVNENEMM. DEIKNKLSVUCGIG.FLKSLCRGFVNKYMDUITEELSTTDAFTICANLSVCK.K. EEIKQKLLSVCGKLP.IVKSTCEDLVKKHLWVLIEELSTDDAFTICVNLFACK.PKEIL.DLSY. EEIKQKLLSVCGKLP.IVKSTCEDLVKKHLWVLDELNTSDGVRTICVNLFACK.PKEVL.DLSY. EEIKQKLLSVCGKUG.FLKSUCKGUKKHLWVLUEELSTSDDVRTICVNLFACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.IVKSTCEDLVKKHLWVLVEELSTSDDVRTICVNLFACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.IVKSTCEDLVKKHLWVLVEELSTSDDVRTICVNLFACK.PKEVL.DLSY. EEIKQKLLSVCGKMG.ILKSICKGWVKKHLWVLVEELSTSDDVRTICVNLFACK.PKEVL.DLSY. EEIKQKLLSVCGKMG.ILKSICKGWVKKHLWVLVEELSTSDDVRTICVNLFACK.PKEVL.DLSY. EEIKQKLLSVCGKMG.ILKSICKGWVKKHLWVLVEELSTSDDVRTICVNLFACK.PKEVL.DLSY. DEIKTKLNDTCMKVG.FLKRQCKRFVEKYLGSLIDEIMTDDGPNTICINLFACK.PKEPILMDLSY. DEIKKKLMVCDKFK.PLRVQCKHFVEKYLGSLIDEIMTDDGPNTICINLFACK.PKEPILMDLSY. DEIKKKLMVCDKFK.PLRVQCKHFVEKYLGSLIDEIMTDDGPNTICINLFACK.FEPIVKPDQAH.DNF. DDIKKKLGSICDEIG.FLKSLCRKFVNKYTDTLVEELSTTDDAFTICWNLGVCK.K. EDIKKKLMVCDKFK.PVSQCKKLVQKYLENIIDELMTEDGPNTICTKLHVCK.SKPPIKEFILVHDQAA.DNF. DDIKKKLGSVCDEIG.FLKSLCRKFVNKYTDTLVEELSTTDDARTICANIGVCK.K. DDVKKKLAMVCDEIG.FLKSLCRKFVKKYLTDILVEELSTTDDARTICINLGVCK.K. DDVKKKLAMVCDEIG.FLKSLCRKFVKKYLTILELSTTDDARTICINIGVCK.KUWNS. DDVKKKLAMVCDEIG.FLKSLCRKFVKKYLTILELSTTDDARTICINIGVCK.KUWS. DDVKKKLAMVCDEIG.FLKSLCRKFVKKYLTILEELSTTDDARTICINIGVCK.KUWS. DDVKKKLAMVCDEIG.FLKSLCRKFVKKYLTIVEELSTTDDARTICINIGVCK.KUWS.	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 129\\ 129\\ 129\\ 129\\ 129\\ 129\\ 129\\ 12$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNKL3) 私点叉尾鮰 Ictalurus punctatus (type1) 私点叉尾鮰 Ictalurus punctatus (type2) 私点叉尾鮰 Ictalurus punctatus (type3) 都马鱼 Danio rerio (nkla) 和马鱼 Danio rerio (nklc) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马扒缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马扒缨鱼 Pseudocrossocheilus bamaensis (PbNkla)	ESVKEKLMRVCNEIG., ILKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK, PKELS., ELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPFSTRUSSACKKVUKRYQDKLINVIADKGTPESICIRLSLCKSRGQ. ARIRCIAMGVCNGFRSRUVSSACKKVUTRYQDYLSNYIAKNGSSRRICARLRLCRRVSQ. DIIKAQLAEVCNSIG., FLRGLCKTIINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMIKAQLAEVCNSIG., FLRGLCKTIINKYLDTLVEELSTTDDPTTICVNIGIC. EKIKEKLKRGCDKLP. VVKDLCKKMVNKNIDFLVEELSTTDDPTTICVNIGIC. DEIKNKLMNLCEKAW. LLKGCCQKFVKTHLHTLIDELMINDGVNTICAKALVCK.FGPPREENFIHDRAVNENERM. DEIKNKLMNLCEKAW. LLKGCCQKFVKTHLHTLIDELMINDGVNTICAKALVCK.FGPPREENFIHDRAVNENERM. DEIKNKLMNLCEKAW. LLKGCCQKFVKTHLHTLIDELMINDGVNTICAKALVCK.FGPPREENFIHDRAVNENERM. DEIKNKLMNLCEKAW. VLKSQCKKFIQKHIHTLIDELMINDGVNTICAKALVCK.SEPPIKEFIFIHDQAYSKL EEILKQLLSVCDGIG.FLRSLCRGFVNKYMDVLIEELSTTDAPRTICANLSVCK.K. ETILKQKLLSVCDKVG.FLKSMCKGIMKHHWVLDELSTSDAVRTICVNIKACK.PKEVL.DLSY. EEILQKLLSVCGKLP.UKSTCEDLVKHLWVVDDIMISDGVRTICVNIKACK.PKEVL.DLSY. EEILQKLLSVCDKVG.FLKSMCKGIMKHHWVLDELSTSDDVRTICVNIKACK.PKEVL.DLSY. EEILQKLLSVCDKVG.FLKSMCKGIMKHHWVLDELSTSDDVRTICVNIKACK.PKEVL.DLSY. EEILQKLLSVCDKVG.FLKSMCKGIMKHHWVIDELMIDDGPNICTIKIHACK.PEPIL.DLSY. EEILQKLLSVCDKMG.LLKSLCKEMVKKHLWVVDELSTSDDVRTICVNIKACK.PKEVL.DLSY. DEIKTKLNNICDKFK.PLRVQCKHFVEKYLGVLDELMIDDGPNICTIKIHACK.EARTIKEFIVHDQAQFINENK. DDIKKKLGSICDEIG.FLKSLCRKFVNQYRDTIVEELSTTDDARTICVNISVCK.K. EDIKKKLGNVCDKKR.PLKSLCRKFVNQYRDTIVEELSTTDDARTICVNISVCK.K. EDIKKKLGNVCDEIG.FLKSLCRKFVNQYRDTIVEELSTTDDARTICVNISVCK.K. DDIKKKLGNVCDEIG.FLKSLCRKFVNQYRDTIVEELSTTDDARTICVNISVCK.K. DDIKKKLGNVCDEIG.FLKSLCRKFVNQYRDTIVEELSTTDDARTICVNIGVCK.K. DDIKKKLGNVCDEIG.FLKSLCRKFVNQYRDTIVEELSTTDDARTICVNIGVCK.K. DDIKKKLGNVCDEIG.FLKSLCRKFVNQYRDTIVEELSTTDDARTICNIGVCK.K. DDIKKKLGNVCDEIG.FLKSLCRKFVNQYRDTIVEELSTTDDARTICNIGVCK.K. DDIKKKLGNVCDEIG.FLKSLCRKFVNQYRDTIVEELSTTDDARTICNIGVCK.K. DDIKKKLGNVCDEIG.FLKSLCRKFVNKYNGTLIEELSTTDDARTICNIGVCK.K. DDIKKKLGNVCDEIG.FLKSLCRKFVNKYNGTLIEELSTTDDARTICNIGCK.KWWSS DEIKNKLGTVCDEIG.FLKSLCRKFVNKYNGTLIEELSTTDDARTICVNIGICK.	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 127\\ 129\\ 129\\ 129\\ 129\\ 129\\ 141\\ 122\\ 121\\ 141\\ 122\\ 121\\ 121\\ 120\\ 120$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNKL3) 延点叉尾鮰 Ictalurus punctatus (type1) 延点叉尾鮰 Ictalurus punctatus (type3) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nkld) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-2) 大西洋鲑 Salmo salar (SsNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla)	ESVKEKLMRVCNEIG., ILKSLCKKFVKGHLGELIEELITSDDVRTICVNLKACK.PKELS., ELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFTRSICEKLVRKYQDKLINVIADKGTPESICIRLSLCKSRGQ. ARIRCIAMGVCNGERSRFVRSACKKVTRRYQTKLSNYIAKNGSSPRICARLRLCRRVSQ. DIIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTDDPTTICVNIGIC. EKIKEKLKRGCDKLP.VVKDLCKKTVNNIDFLVEELSTDDDPKAICAKAGLCK.PVDMWELIQAFPQNYQKL. DEIKNKLMNLCEKAW.LLKGCQCKFVKTHLHTLIDELMINDGVNTICAKALVCK.FCPPREEFNFIHDRAVNENERM. DEIKNKLMNLCEKAW.LLKGCQCKFVKTHLHTLIDELMINDGVNTICAKALVCK.FCPPREEFNFIHDRAVNENERM. DEIKNLSQVCDQIG.FLRFLCRGFVKKYMDULTEELSTDDPRTICTKVHACK.SEPPIKEFIFIHEQAYS.KL EEILKQLLSVCDKG.FLKSMCKGIMKKHLWVLIEELSTDDARTICANISVCK.K. ETILQKLLSVCGKLP.LVKSTCEDLVKKHLWVVIDFLNTSDGVRAICVKIKACK.PKEVL.DLSY. EEIKQKLLSYCGKLP.LVKSTCEDLVKKHLWVVIDELMTSDGVRAICVKIKACK.PKEVL.DLSY. DEIKVQLSVCDQUG.FLKSLCKGVKKYMVINELESTSDDVRTICVKIKACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.LVKSTCEDLVKKHLWVVIDELMTSDGVRAICVKIKACK.PKEVL.DLSY. DEIKVLSVCDKVG.FLKSLCKGVVKYHLWVIDELMTSDGVRAICVKIKACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.FLKSCCKFVEKYLHGVIDELMTDDGPNTICIKIRACK.PKEVL.DLSY. DEIKTKLNNICDKKK.PLKVCKHVEKYLSSIDDVRTICVNIKACK.PKEVL.DLSY. DEIKTKLNNICDKKF.PLKVCKHVEKYLSSIDDVRTICVNIKACK.PKEVL.DLSY. DEIKTKLNNICDKKK.PLKVCKHVEKYLSSIDDVRTICVNIKACK.PKEVL.DLSY. DEIKTKLNNICDKKK.PLKVCKHVEKYLSSIDDVRTICVNIKACK.FEFIVVHDQAPINENK. DDIKKKLGSVCDKG.FLKSLCRKFVKKYKMIVIDELSTDDPRTICVNISVCK.K. DEVNRQLDRICKRIR.IG.CTRFVQKYLVNILILSGDKASTICVNIGVCK.K. DEVNRQLDRICKRIR.FLSCRKFVKKYKMTIVEELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEID.SLKSLCRKFVKKYKMTILEELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEID.SLKSLCRKFVKKYKMTILEELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEID.SLKSLCRKFVKKYKMTILEELSTTDDARTICVNIGVCK.KUWSS DEIKNKLGTVCDQGG.FLKSLCRKFVKKYKMTILEELSTTDDARTICVNIGVCK.KUWS DEIKNKLGTVCDQGG.FLKSLCRKFVKKYKMTILEELSTTDDARTICVNIGCK.KUWS DEIKNKLGTVCDQGG.FLKSLCRKFVKKYKMTILEELSTTDDARTICVNIGCK.KUWS DEIKNKLGTVCDQGG.FLKSLCRKFVKYKMTILEELSTTDDARTICVNIGCK.KUWS DEIKNKLGTVCDQGG.FLKSLCRKFVKYKMTILEELSTTDDARTICVNIGGC. DDIKKKLAMVCDEID.SLKSLCRKFVKYKMTILEELSTTDDARTICVNIGGC.	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 119\\ 121\\ 129\\ 129\\ 129\\ 129\\ 129\\ 12$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NkL2) 大黄鱼 Larimichthys crocea (LcNkL3) 粧点叉尾鮰 Ictalurus punctatus (type1) 斑点叉尾鮰 Ictalurus punctatus (type2) 斑点叉尾鮰 Ictalurus punctatus (type3) 斑马鱼 Danio rerio (nkla) 斑马鱼 Danio rerio (nkla) 斑马鱼 Danio rerio (nkld) 大西洋鲑 Salmo salar (SNK-lysin-1) 大西洋鲑 Salmo salar (SNK-lysin-2) 大西洋鲑 Salmo salar (SNK-lysin-3) 大西洋鲑 Salmo salar (SNK-lysin-3) 大西洋鲑 Salmo salar (SNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 민马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb) 민马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马拟ccapio (Nkl1) 樫鱼 Cyprinus carpio (Nkl1) 樫鱼 Cyprinus carpio (Nkl3) 樫鱼 Cyprinus carpio (Nkl4) 樫鱼 Cyprinus carpio (Nkl5) 樫鱼 Cyprinus carpio (Nkl6) 团头鲂 Megalobrama amblycephala (nkla)	ESVKEKLMRVENEIG. ILKSLCKKFVKGHLGELIEELITSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGILAKACNGLRPRFTRSICEKLVRKYQDKLINVIADKGTPESICIRLSLCKSRGQ	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 119\\ 121\\ 129\\ 129\\ 136\\ 141\\ 112\\ 129\\ 136\\ 141\\ 112\\ 121\\ 141\\ 122\\ 126\\ 121\\ 120\\ 112\\ 122\end{array}$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNKL3) 私点又尾鮰 Ictalurus punctatus (type1) 死点又尾鮰 Ictalurus punctatus (type2) 斑马鱼 Danio rerio (nkla) 斑马鱼 Danio rerio (nkla) 斑马鱼 Danio rerio (nklc) 斑马鱼 Danio rerio (nklc) 斑马鱼 Danio rerio (nklc) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟g鱼 Cyprinus carpio (Nkl3) 俚鱼 Cyprinus carpio (Nkl3) 俚鱼 Cyprinus carpio (Nkl4) 香鱼 Cyprinus carpio (Nkl5)	ESVKEKLMRVCNEIG. ILKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPFIRSICEKLVRKYQDKLINVIADKGTPESICIRLSLCKSRGQ	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 129\\ 129\\ 136\\ 141\\ 144\\ 122\\ 121\\ 112\\ 122\\ 121\\ 120\\ 112\\ 122\\ 12$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNKL3) 私点叉尾鮰 Ictalurus punctatus (type1) 私点叉尾鮰 Ictalurus punctatus (type2) 私点叉尾鮰 Ictalurus punctatus (type3) 秘马鱼 Danio rerio (nkla) 秘马鱼 Danio rerio (nkla) 赵马鱼 Danio rerio (nkld) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-2) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-4) 马叔纓鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马叔纓鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马叔纓鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马叔缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马叔 (PbNkla) 里鱼 Cyprinus carpio (Nkl1) 瞿鱼 Cyprinus carpio (Nkl3) 瞿鱼 Cyprinus carpio (Nkl4) 瞿鱼 Cyprinus carpio (Nkl4) 瞿鱼 Cyprinus carpio (Nkl4) 霍鱼 Cyprinus carpio (Nkl4) 霍鱼 Cyprinus carpio (Nkl4) 霍鱼 Cyprinus carpio (Nkl4) 香鱼 Syminus carpio (Nkl4)	ESVKEKLMRVCNEIG., ILKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELS., ELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFIRSICEKLVRKYQDKLINVIADKGTPESICIRLSLCKSRGQ. ARIRCIMGVCNGFRSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRLCRVSQ. DIIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTTDDPTTICVNIGIC. EKIKEKLKRGCDKLP.VVKDLCKKTVNKYLDTLVEELSTTDDPTTICVNIGIC. EKIKEKLKRGCDKLP.VVKDLCKKTVNKNIDFLVEELSTDDDPKAICAKAGLCK.PVDMWELIQAFPQNYQKL. DEIKNKLMNLCEKAW.LLKGCCCKFVCHLHTLIDELMINDGVNTICAKALVCK.FGPRKEFNFHDRAVNENERM. DEIKNKLMNLCEKAW.LLKGCCKFVCKYLMVILTELSTDDPTICVNIGIC. EKIKEKLSKGCDKLP.VVKSCCKFFQKHIHTLIDELMINDGVNTICAKALVCK.FGPRKEFNFHDRAVNENERM. DEIKNKLMNLCEKAW.LLKGCCKFVKYMDVLIEELSTDDPTICTKVHACK.SEPPIKEFIFIHEQAYS.KL EEIKQKLSVCDKG.FLKSMCKGIMKKHLWVLIEELSTDDPTICVNIKACK.PKEVL.DLSY. EEIKQKLSVCDKVG.FLKSMCKGIMKKHLWVVIDELNTSDGVRAICVKIKACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.UKSTCEDLVKKHLWVVIDELNTSDGVRAICVKIKACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.UKSTCEDLVKKHLWVVIDELMTDDGPNTICINIKACK.PKEVL.DLSY. DEIKTKLNNICDKK.PLKVCKFVKYTDTIVEELSTDDPRTICVNIKACK.PKEVL.DLSY. EEIKQKLLSVCGKLP.UKSTCEDLVKKHLWVVIDELMTDDGPNAICTKIHVKK.EARTIKEFIVVHDQAQFINENK. DEIKTKLNNICDKK.PLKVCKFVKYTDTIVEELSTDDPRTICVNISVCK.K. EDIKKKLGSIGDEIG.FLKSICRFVNQYRDTIVEELSTDDPRTICVNISVCK.K. EDIKKKLGSIGDEIG.FLKSICRFVNQYRDTIVEELSTDDPRTICVNISVCK.K. DDIKKKLGSIGDEIG.FLKSICRFVNQYRDTIVEELSTTDDARTICVNIGVCK.K. DDIKKKLGSIGDEIG.FLKSICRFVNQYRDTIVEELSTTDDARTICVNIGVCK.K. DDIKKKLGNVCDKR.PVSQCKKVVKYLDTIVEELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEID.SLKSICRFVNKYNTDIIVEELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEID.SLKSICRKFVNKYNTDIVEELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEID.SLKSICRKFVNKYNTDIIVEELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEID.SLKSICRKFVNKYNTDIIVEELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEID.SLKSICRKFVNKYNTDIELESTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEID.SLKSICRKFVNKYNTDIELESTTDDARTICVNIGVCK.K. DDIKKKLAMVCDEID.SLKSICRKFVNKYNTDIELESTTDDARTICVNIGCK. EEINQKLDRICQGI.FLKSICRKFVNKYNTDIELESTTDDARTICVNIGCK.KWNSS. DEIKKLGSTVCDQIG.FLKSICRKFVNKYNTDIELESTTDDARTICVNIGCK.KUNSS. DEIKKLGSTVCDQIG.FLKSICRKFVKYNKYNSLLSGDKAGTICIKLKLCKKMNMQTIQ. EEINQKLDRICQKIR.SKCKHVEKYLSTLIDELMTDDCFTICVNIGCK.K. DEIKKKLSNVCD	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 129\\ 129\\ 129\\ 129\\ 129\\ 129\\ 141\\ 144\\ 122\\ 121\\ 122\\ 126\\ 121\\ 120\\ 112\\ 120\\ 136\\ 147\\ \end{array}$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNKL3) 延点叉尾鮰 Ictalurus punctatus (type1) 延点叉尾鮰 Ictalurus punctatus (type2) 延点叉尾鮰 Ictalurus punctatus (type3) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nkla) 赵马鱼 Danio rerio (nkld) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-2) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马扒缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马扒��鱼 (Sprimus carpio (Nkl1) 瞿鱼 (Sprimus carpio (Nkl3) 瞿鱼 (Sprimus carpio (Nkl3) 瞿鱼 (Sprimus carpio (Nkl4) 墨鱼 (Sprimus carpio (Nkl5) 墨鱼 (Sprimus carpio (Nkl5)	ESVKEKLMRVCNEIG. ILKSLCKKFVKGHLGELIEELITSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLLAKACNGLRPRFTRSICEKLVRKYQDKLINVIADKGTPESICIRLSLCKSRGQ. ARIRCIAMGVCNGERSRFVRSACKKVTRRYQTKLSNYIAKNGSSPRICARLRLCRRVSQ. DIIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMIKAQLAEVCNSIG.FLRGLCKTINKYLDTLVEELSTDDPTTICVNIGIC. EKIKEKLKRGCDKLP.VVKDLCKKTVNNIDFLVEELSTDDDPTTICVNIGIC. DEIKNKLMNLCEKAW.LLKGCQCKFVKTHLHTLIDELMINDGVNTICAKALVCK.FCPPREEFNFIHDRAVNENERM. DEIKNKLMNLCEKAW.LLKGCQCKFVKTHLHTLIDELMINDGVNTICAKALVCK.FCPPREEFNFIHDRAVNENERM. DEIKNVLJQVCDGIG.FLRFLCRGFVKKYMDVLIEELSTDDPTTICTKVHACK.SEPPIKEFIFIHDPAVNENERM. DEIKNVLJQVCDGIG.FLKSLCRGFVKKYMDVLIEELSTDDARTICANISVCK.K. ETIKQKLLSVCDKVG.FLKSMCKGIMKKHLWVLVELESTSDDVRTICVNIKACK.PKEVL.DLSY. EEIKQKLLSYCGKLP.IVKSTCEDLVKKHLWVVIDELMTSDGVRAICVKIKACK.PKEVL.DLSY. DEIKVQLSVCDKVG.FLKSMCKGIMKHLWVVIDELMTSDGVRAICVKIKACK.PKEVL.DLSY. EEIKQKLLSYCGKLP.IVKSTCEDLVKKHLWVVIDELMTSDGVRAICVKIKACK.PKEVL.DLSY. DEIKVLSVCDKVG.FLKSUCKHVEKYLJGSUDELMTDDGPNTICINIKACK.PKEVL.DLSY. DEIKVKLSVCDKVG.FLKSUCKHVEKYLJGSUDELMTDDGPNTICIKIRACK.PEPIKEFIVVRDQAH.DNF. DEIKVKLMVCDKFK.PLRVQCKHVEKYLJSLDELMTDDGPNTICIKIRACK.PEPIKEFIVVRDQAH.DNF. DEIKVKLMVCDKFK.PLRVQCKHVEKYLJSLDELMTDDGPNTICIKIRACK.PEPIKEFIVVRDQAH.DNF. DEIKKLGNVCDKFK.PLSCRKFVKKYDTIVEELSTTDDARTICVNISVCK.K. DEVNRQLDRICKRIR.IG.CTRFVQKYLDYIDIVEELSTTDDARTICVNISVCK.K. DEVNRQLDRICKRIR.IG.CTRFVQKYKNKIVILELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDEIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICVNIGVCK.K. DDVKKKLAMVCDIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICVNIGUCK.KUWSS DEIKNKLGTVCDQIG.FLKSLCRKFVKYMKYMGTLIEELSTTDDARTICVNIGUCK.KUWSS DEIKNKLGTVCDQIG.FLKSLCRKFVKYMKYMGTLIEELSTTDDARTICVNIGUCK.KUWSS DEIKNKLGTVCDQIG.FLKSLCRKFVKYMKYMGTLIEELSTTDDARTICVNIGUCK.KPEPPIKEFILAFNSL EENKKLINVINKERFILAFFILFFILDELSTTDDARTICVNIGUCK.K. DEIKKKLSMVCDQIG.FLKSLCRKFVKYMLGELESTTDDARTICVNIGU	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 127\\ 129\\ 129\\ 129\\ 129\\ 129\\ 121\\ 141\\ 122\\ 121\\ 112\\ 121\\ 121\\ 122\\ 126\\ 121\\ 121$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NkL2) 大黄鱼 Larimichthys crocea (LcNkL3) 延点叉尾鮰 Ictalurus punctatus (type1) 延点叉尾鮰 Ictalurus punctatus (type2) 延点叉尾鮰 Ictalurus punctatus (type3) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nklb) 达马维 Balmo salar (SNK-lysin-1) 大西洋鲑 Salmo salar (SNK-lysin-2) 大西洋鲑 Salmo salar (SNK-lysin-3) 大西洋鲑 Salmo salar (SNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马拟g鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马叔g鱼 Pseudocrossocheilus bamaensis (PbNklb) 王子叔g鱼 Pseudocrossocheilus	ESVKEKIMRVCNEIG., LIKSLCKKFVKGHLGELIEELITTSDDVRTICVNLKACK. PKELSELDFESDEDAHTEMNDLLF AKIQGLAKACNGLRPRFIRSICEKLVRKVQDKLINVIAKGSPREICIRLSLCKSRGQ. ARTRCIMMGVCNGFRSRFVRSACKKVTRRVQVRLSNVIAKNGSSRRICARLRICRRVSQ. DIIKAQLKKVCNSIG. FLRGLCKKMINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMIKAQLAEVCNSIG. FLRGLCKTIINKYLDTLVEELSTTDNFTTICVNIGIC. EKIKEKLKRCDKLP. VVKDLCKKMVNKNIDTLVEELSTTDNFTTICVNIGIC. DEIKNKLMRICEKAW.LLKGQCQKFVKTHLHTLIDELMINDGVNTICAKALVCK.FGPPRKEFNFIHDRAVNENEKM. DEIKNKLMNICKAV.VLKSQCKKFTQKHHHTLIDELMINDGVNTICAKALVCK.FGPPRKEFNFIHDRAVNENEKM. DEIKNKLMNICKAV.VLKSQCKKFTQKHHHTLIDELMINDGPNTICTKVHACK.SEPPIKEFTFHHQAYSKL. EEKIKQLSQVCDGIG.FLKSLCRGFVNKMDVLIEELSTTDARTICANISVCK.K. ETLKQKLSVCDKVG.FLKSNCKGIMKKHWVLIDELNTSDGPRTICVNIKACK.PKEIL.DLSY. EEKIKKLNSVCDKVG.FLKSNCKGIMKKHWVLIDELNTSDGVRTICVNIKACK.PKEIL.DLSY. EEKIKKLNNICVKKV.PKSTCEDLVKKHHWVVIDELNTSDGVRTICVNIKACK.PKEVL.DLSY. EEKIKKLSVCDKVG.LLKSLCKGWKKHHWVVIDELMTSDGVRTICVNIKACK.PKEVL.DLSY. EEKIKKLSVCDKMG.LLKSLCKGWKKHHWVVIDELMTSDGVRTICVNIKACK.PKEVL.DLSY. DEIKTKINNICOKKV.PLKVQCKRFVEKXHGULDELSTSDDVRTICINIKACK.PKEVL.DLSY. EEKIKKLSVCDKMG.LLKSLCKGWKKHHWVVIDELMTSDGVRTICVNIKACK.PKEVL.DLSY. DEIKTKINNICOKKV.PLKVQCKRFVEKXLGSLIDELMTDDGFNITCIKHVCK.PARTIKEFTVVHDQAH.DNF. DEIKTKINNICOKKK.PLKVQCKRFVEKXLGSLIDELMTDDGFNITCIKHVCK.PARTIKEFTVVHDQAH.DNF. DEIKTKINNICOKKK.PLKVQCKKLVQXLIDELMTDDGFNITCIKHVCK.SKPFIKEFTLVHDQAH.DNF. DEIKKKLGWCDEIG.FLKSLCRKFVNKYTDTIVEELSTTDDARTICVNISVCK.K. DEVNRQLDRICKRIR.RG.TRFLQXYRNKVTDTIVEELSTTDDARTICNNIGVCK.K. DDIKKKLGWCDEIG.FLKSLCRKFVNKYTDTIVEELSTTDDARTICNNIGVCK.K. DDIKKKLGWCDEIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICNNIGVCK.K. DDIKKKLGWCDEIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICNNIGVCK.K. DDIKKKLGWCDEIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICNNIGVCK.K. DDIKKKLGWCDEIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICNNIGVCK.K. DDIKKKLGWCDEIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICNNIGVCK.K. DDIKKKLGWCDEIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICNNIGVCK.K. DDIKKKLGWCDEIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICNNIGVCK.K. DEIKTKLNNTCEKAR.LLKSKCKHFVEKYLSTLIDELMTDDGFKTICIKNACK.PEPPIKEFTLAFNSL. ESNKAKLNVCNEIG.FLKSCKHFVEKYLSTLIDELVEL	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 129\\ 129\\ 129\\ 129\\ 129\\ 136\\ 141\\ 122\\ 121\\ 112\\ 121\\ 122\\ 136\\ 122\\ 135\\ 121\\ 135\\ 121\\ 121\\ 122\\ 135\\ 121\\ 121\\ 135\\ 121\\ 121\\ 122\\ 135\\ 121\\ 135\\ 121\\ 121\\ 122\\ 135\\ 121\\ 121\\ 122\\ 135\\ 121\\ 121\\ 122\\ 135\\ 121\\ 121\\ 122\\ 135\\ 121\\ 121\\ 122\\ 135\\ 121\\ 121\\ 122\\ 135\\ 121\\ 121\\ 122\\ 135\\ 121\\ 121\\ 122\\ 135\\ 121\\ 121\\ 122\\ 135\\ 121\\ 121\\ 122\\ 135\\ 121\\ 121\\ 122\\ 135\\ 121\\ 121\\ 122\\ 122\\ 122\\ 122\\ 122\\ 12$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNkL3) 私点又尾鮰 Ictalurus punctatus (type1) 私点又尾鮰 Ictalurus punctatus (type2) 私点又尾鮰 Ictalurus punctatus (type3) 秘马鱼 Danio rerio (nkla) 和马鱼 Danio rerio (nklc) 赵马鱼 Danio rerio (nkld) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-2) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟g鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟g鱼 Pseudocrossocheilus bamaensis (PbNkla) 里鱼 Cyprinus carpio (Nkl1) 霍鱼 Cyprinus carpio (Nkl3) 霍鱼 Cyprinus carpio (Nkl5) 霍鱼 Cyprinus carpio (Nkl5) 霍鱼 Cynoglossus semilaevis 声鱼 Ctenopharyngodo idella 罗鱼 Cienopharyngodon idella	ESVKEKIMRVCNEIG., LIKSLCKKFVKGHLGELIEELITTSDDVRTICVNLKACK. PKELSELDFESDEDAHTEMNDLLF AKIQGLAKACNGLRPRFIRSICEKLVRKYQDKLINVIAKGSPRSICIRLSLCKSRGQ. ARTRCIMMGVCNGFRSRFVRSACKKVTRRVQVRLSNVIAKNGSSRRICARLELCRRVSQ. DIIKAQLAKVCNSIG. FLRGLCKTIINKYLDTIVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHKQI. DMKAQLAEVCNSIG. FLRGLCKTIINKYLDTIVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQNYQKL. EKIKEKLKRGCDKLP. VVKDLCKKMVNKNLDFUVEELSTTDDPKATCAKALCK.PVDMWELLQAFPQNYQKL. DEIKNKIMMICEKAW.LLKGQCQKFVKTHLHTLIDELMINDGVNTICAKALCK.FGPPRKENFIHDRAVNENERM. DEIKNKIMMICEKAW.LLKGQCQKFVKTHLHTLIDELMINDGPNTICKAKALCK.FGPPRKENFIHDRAVNENERM. DEIKNQLSQVCDGIG.FLRSLCRGFVNKMDVLIEELSTTDDPTTICKVHACK.SEPPIKEFIFHHQAYSKL EEIKQKLSVCDKVG.FLKSUCKGIMKKHLWVLIEELSTDDPTTICKVHACK.PKEIL.DLSY. EEIKQKLSVCDKVG.FLKSUCKGIMKKHLWVLIEELSTDDVRTICVNIKACK.PKEIL.DLSY. EEIKQKLSVCDKVG.FLKSUCKGIMKKHLWVLIEELSTDDVRTICVNIKACK.PKEIL.DLSY. EEIKQKLSSCCKLP.UKSTCEDLVKKHLWVVIDELMSDGVRTICVKIKACK.PKEIL.DLSY. EEIKQKLSSCCKLP.UKSTCEDLVKKHLWVVIDELMSDGVRTICVKIKACK.PKEIL.DLSY. EEIKQKLSSCCKLP.UKSTCEDLVKKHLWVVIDELMSDGVRTICVKIKACK.PKEIL.DLSY. EEIKQKLSSCCKLP.UKSTCEDLVKKHLWVVIDELMIDDGPNITCINIKACK.PKEIL.DLSY. EEIKQKLSSCCKLP.UKSTCEDLVKKHLWVVIDELMIDDGPNITCINIKACK.PKFIL.DLSY. DEIKKKLSSCCKLP.PLRVQCKHFVEKYLQSLIDELMIDDGPNITCINIKACK.PKFIL.DLSY. EEIKQKLSSCCKLP.FLKSLCKFVVKYDTDIVEELSTDDPRTICVNIGVK.K. EDIKKKLGSICDEIG.FLKSLCRKFVVKYDTIVVELSITDDPRTICVNISVCK.K. EDIKKKLGSICDEIG.FLKSLCRKFVVKYDTIVVELSITDDPRTICVNISVCK.K. EDIKKKLGSICDEIG.FLKSLCRKFVVKYDTIVEELSTTDDAKTICVNIGVCK.K. DDVKKKLAMVCDEIG.FLKSLCRKFVVKYDTIVEELSTTDDAKTICVNIGVCK.K. DDVKKKLAMVCDEIG.FLKSLCRKFVVKYDTIVEELSTTDDAKTICVNIGVCK.K. DDVKKKLAMVCDEIG.FLKSLCRKFVVKYDTIVEELSTTDDAKTICVNIGVCK.K. DDVKKKLAMVCDEIG.FLKSLCRKFVKYNTDTIVEELSTTDDAKTICVNISVCK.K. DDVKKKLAMVCDEIG.FLKSLCRKFVKYNTDTIVEELSTTDDAKTICVNIGVC.K. DEIKNLGTVCDGIG.FLKSLCRKFVKYNTDTIVEELSTTDDAKTICVNISVCK.K. DDVKKKLAMVCDEIG.FLKSLCRKFVKYNTDTIVEELSTTDDAKTICVNISVCK.K. ESIKSKLNVICNEIG.LLKSLCRKFVKKHLGELIEELTTDDVKTICVNVGQO.PKEVA.HLLFPRHDESQTEIIEYP. EXVKALLINCOKKR.LLSCRKFVKHLGELIEELSTTDDAKTICVNISVCK.K. DDVKRKLAMVCDEIG.FLKSCRKFVKHLGELIEELSTTDDAKT	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 119\\ 127\\ 129\\ 136\\ 141\\ 112\\ 122\\ 126\\ 141\\ 122\\ 121\\ 120\\ 112\\ 122\\ 136\\ 147\\ 135\\ 121\\ 143\\ 143\\ 143\\ 143\\ 143\\ 143\\ 143\\ 14$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NkL2) 大黄鱼 Larimichthys crocea (LcNkL3) 粧点叉尾鮰 Ictalurus punctatus (type1) 斑点叉尾鮰 Ictalurus punctatus (type3) 斑马鱼 Danio rerio (nkla) 斑马鱼 Danio rerio (nkla) 斑马鱼 Danio rerio (nkla) 斑马鱼 Danio rerio (nkld) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-2) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲢 Salmo salar (SsNK-lysin-3) 大西洋鲢 Salmo salar (SsNK-lysin-4) 马利以饗鱼 Pseudocrossocheilus bamaensis (PbNkla) 민马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟 Pseudocrossocheilus bamaensis (PbNkla) 里鱼 Cyprinus carpio (Nkl1) 瞿鱼 Cyprinus carpio (Nkl1) 瞿鱼 Cyprinus carpio (Nkl1) 瞿鱼 Cyprinus carpio (Nkl2) 霍鱼 Cyprinus carpio (Nkl3) 霍鱼 Cyprinus carpio (Nkl3) 霍鱼 Cyprinus carpio (Nkl4) 霍鱼 Cy	ESVKEKIMRVONEIGLIKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK.PKELSELDFESDEDAHTEMNDLLF AKIQGLAKACNGLRPRFTRSICEKLVRKYQKLINVIADKGYPESICIRLSLCKSRGQA ARIRCIMMGVCNGEFSRVBACKKVTRRYQYRLSNVIANGSSRRICARLRICRWSQ DIIKAQLAEVONSIG.FLRGLCKHIINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQHHQI DMIKAQLAEVONSIG.FLRGLCKTIINKYLDTLVEELSTTDDPTTICGNLGICK.SLSMLELFQAFPQNYQKL DEIKKELKRGCDKLP.VVKDLCKKMVNKNLDFLVEELSTDDDPKAICAKAGLCK.PVDMWELIQAFPQNYQKL DEIKNKIMNLCEKAW.LLKGQCQKFVKTHLHTLIDELMINDGGWTICAKAGLCK.PVDMWELIQAFPQNYQKL DEIKNNLMNICKAV.VLKSQCKKFIQKHHTLIDELMINDGGWTICAKAGLCK.PVDMWELIQAFPQNYQKL DEIKNIAMICEKAW.LLKGQCQKFVKTHLHTLIDELMINDGGWTICAKAGLCK.FGPPRKEFNFHDRAVNENEKM DEIKNILMVICKAV.VLKSQCKKFIQKHHTLIDELSTDDPKAICAKAGLCK.PEPPIKEFIFHHQAYS.KL EEIKNQLSQVCDQIG.FLKSLCRGFVNKYMDVLIEELSTDDARTICANISVCK.K. ETLKQKLSVCDKVG.FLKSMCKGHMKHLWVLIEELSTDDARTICANISVCK.K. ETLKQKLSYCGKLP.LVKSTCEDLVKKHLWVVIDELNTSDGVRTICVKIKACK.PKEVL.DLSY. EEIKQKLLSYCGKLP.LVKSTCEDLVKKHLWVVIDELNTSDGVRTICVKIKACK.PKEVL.DLSY. DEIKTKLNIDCMKKG.PLKRQCKFVEKYHGVIDELMTDDGFNTICINIKACK.PKEVL.DLSY. EEIKQKLLSVCDKG.LLKSLCKGVKFVEKYHGVIDELMTDDGFNTICINIKACK.PKEVL.DLSY. DEIKTKLNNICDKFK.PLRQCKFVEKYHGVIDELMTDDGFNTICINIKACK.PKEVL.DLSY. EEIKQKLLSVCDKG.FLKSLCRKFVNQYTDTIVEELSTDDDRTICVNIGXCK.K. EDIKKKLAMVCDEIG.FLKSLCRKFVNQYTDTIVEELSTDDARTICVNIGVCK.K. EDIKKKLAMVCDKFK.PUSQCKKLVKQTDTIIDELMTDDGFNTICINIKQCK.KSVPIKEFILVHDQAFI.MENK. DDIKKKLAMVCDKFK.PUSQCKKLVKYTDTIVEELSTTDDARTICVNIGVCK.K. DDIKKKLAMVCDGIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICVNIGVCK.K. DEIKNLLAWVCDGIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICVNIGVCK.K. DEIKNLAMVCDGIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICVNIGVCK.K. DEIKNLAMVCDGIG.FLKSLCRKFVNKYMGTLIEELSTTDDARTICVNIGVCK.K. DEIKNKLAMVCDQIG.FLKSCRKFVNKYMGTLIEELSTTDDARTICVNIGVCK.K. DEIKNKLAMVCDGIG.FLKSCRKFVNKYMGTLIEELSTTDDARTICVNIGVCK.K. DEIKNKLAMVCDGIG.FLKSCRKFVNKYMGTLIEELSTTDDARTICVNIGVCK.K. DEIKNKLAMVCDGIG.FLKSCRKFVNKYMGTLIEELSTTDDARTICVNIGVCK.K. DEIKNKLAMVCDGIG.FLKSCRKFVNKYMGTLIEELSTTDDARTICVNIGAC.PKEPS.HLLFPPNN. SUKRALSHVDDEIG.FLKSCRKFVNKHGVLIEELSTTDDARTICVNKACN.PKEPS.HLLFPYENDSQTEILEYP. EKVKARLIKIONKGG	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 121\\ 127\\ 129\\ 129\\ 129\\ 122\\ 121\\ 112\\ 122\\ 126\\ 121\\ 112\\ 122\\ 12$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NkL2) 大黄鱼 Larimichthys crocea (LcNKL3) 延点叉尾鮰 Ictalurus punctatus (type1) 延点叉尾鮰 Ictalurus punctatus (type2) 延点叉尾鮰 Ictalurus punctatus (type3) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nkld) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-2) 大西洋鲑 Salmo salar (SsNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马拟g鱼 Pseudocrossocheilus bamaensis (PbNklb) 里鱼 Cyprinus carpio (Nkl1) 里鱼 Cyprinus carpio (Nkl1) 里鱼 Cyprinus carpio (Nkl5) 里鱼 Cyprinus carpio (Nkl5) 里鱼 Cyprinus carpio (Nkl5) 里鱼 Cyprinus carpio (Nkl6) 西曼 Dyprinus carpio (Nkl6) 西曼 Dypri	ESVKEKIMRVONEIG. LLKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK, PKELSELDFESDEDAHTEMNDLLF AKIQGLAKACNGLPREFIRSICKKVTRRYQYRLSNYIAKNGSPESICIRLSLCKSRGQ. ARIRCIMASVONGFESRIVRSACKKVTRRYQYRLSNYIAKNGSPESICIRLSLCKSRGQ. DIIKAQLAKVONSIG. FLRGLCKMINKYLDTLVEELSTDDPTTICGNLGICK, SLSMLELFQAFPQHHQI. DMIKAQLAKVONSIG. FLRGLCKTINKYLDTLVEELSTDDPTTICGNLGICK, SLSMLELFQAFPQHHQI. DMIKAQLAKVONSIG. FLRGLCKTINKYLDTLVEELSTDDDFTICGNLGICK, SLSMLELFQAFPQHHQI. DEIKNLMMLCKAM, LLKGQCKFVKTHLHTLIDELMINDGWTICAKALVCK, PEPPIKEFIFIHDRAVNENEKM. DEIKNNIMICNKAV. VLKSQCKFVKTMLHTLIDELMINDGWTICAKALVCK, SEPPIKEFIFIHDRAVNENEKM. DEIKNNIMICNKAV. VLKSQCKFVKTMUVLIEELSTDDDFTICGNLGKK, SEPPIKEFIFIHDRAVNENEKM. DEIKNLMSUCNKG, FLKSLCRGFVNKYMDVLIEELSTDDARTICANISVCK, K. ETLKQKLLSVCKKG, FLKSMCKGMKKHLWVVIDEINTSDGWRTICVNIKACK, PKEVL. DLSY. EEIKQKLLSVCKG, PLKSMCKGMKKHLWVVIDEINTSDGWRTICVNIKACK, PKEVL. DLSY. UVSTCGDLVKKHLWVVIDEINTSDGWRTICVNIKACK, PKEVL. DLSY. DEIKNLNDTOMKVG. PLKSMCKGMKKHLWVVIDEINTSDGWRTICVNIKACK, PKEVL. DLSY. EEIKQKLSVCKGKG. FLKSMCKRVKKHLWVVIDELMTDDGPNTICTKINKACK, PKEVL. DLSY. DEIKTKLNDTOMKVG. PLKRQCKRFVEKYLQSLIDELMTDDGPNTICTNIKACK, PKEVL. DLSY. DEIKKLSICDEIG. FLKSLCRFVNKYTDTIVEELSTDDARTICVNIKACK, PKEVL. DLSY. DEIKKKLSVCDKFG. PLKSCCRFVEKYLQSLIDELMTDDGPNTICTNIKACK, PKEVL. DLSY. DDIKKKLSVCDKFG. FLKSLCRFFVNKYTDTIVEELSTDDARTICVNIKACK, PKEVL. DLSY. DDIKKKLSVCDKFG. PLKSCCRFVEKYLQSLIDELMTDDGPNTICTNIKVCK, K. EDIKKKLSVVDEGI. FLKSLCRFFVNKYTDTIVEELSTDDARTICNIGVCK, K. DDIKKKLSVVDEGI. FLKSLCRKFVNKYTDTIVEELSTDDARTICNIGVCK, K. DEIKKLLSVCDKFG. PUSCYKNKVTNDILSELSTDDARTICNIGVCK, SKPPIKEFILVHDQAH. DNF. DDIKKKLSVVDEGI. FLKSLCRKFVNKYTDTIVEELSTDDARTICNIGVCK, KUWSS DEIKNLAMVDEID. SLKSLCRKFVNKYTDTIVEELSTDDARTICNIGVCK, K. DDIKKKLSVVDEGI. FLKSLCRKFVNKYTDTIVEELSTDDARTICNIGVCK, K. DDIKKKLSVVDEGI. FLKSLCRKFVNKYTDTIVEELSTDDARTICNIGVCK, K. DDIKKKLSVVDEGI. FLKSLCRKFVNKYTDIVEELSTDDARTICNIGVCK, K. DDIKKKLSVVDEGI. FLKSLCRKFVNKYTDIVEELSTDDARTICNIGVCK, K. DDIKKKLSVVDEGI. FLKSLCRKFVNKYTDIVEELSTDDARTICNIGCK, SKPEIKEFILAPNSL. ESWKSKLSSIONEGI. LLKSLCRKFVKKHLGELIEELTTDDVRTICVNKACR, PKEPS. HLLFYPRNS. SIKKS	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 127\\ 129\\ 129\\ 129\\ 129\\ 129\\ 129\\ 121\\ 121$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNkL3) 私息又尾鮰 Ictalurus punctatus (type1) 私息又尾鮰 Ictalurus punctatus (type2) 私島又尾鮰 Ictalurus punctatus (type3) 私島又尾鮰 Ictalurus punctatus (type3) 私日鱼 Danio rerio (nkla) 私日鱼 Danio rerio (nklc) 私日鱼 Danio rerio (nklc) 和日鱼 Danio rerio (nklc) 大西洋蛙 Salmo salar (SsNK-lysin-1) 大西洋蛙 Salmo salar (SsNK-lysin-3) 大西洋蛙 Salmo salar (SsNK-lysin-4) 巴马叔缓鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马叔缓鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马叔银鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马叔银鱼 Pseudocrossocheilus bamaensis (PbNkla) 里鱼 Cyprinus carpio (Nkl3) 霍鱼 Cyprinus carpio (Nkl3) 霍鱼 Cyprinus carpio (Nkl4) 香香 Crenopharyngodon idella Bit Ctonopharyngodon idella Bit Caronpharyngodon idella Bit Boleophthalmus maximus Bithe Boleophthalmus pectinirostris	ESVKEKIMRV.NEIGLLKSI/KKFVKGHLGELIEELTTSDDVRTICVNLKACK, PKELSELDFESDEDAHTEMNDLLF AKIQGLAKACNGLEPRFIRSICKLVRKYQKLINVIADKGPPESICIRLSLCKSRGQ ARIRCIMMGV.NGFRSRFVRSA/KKVTRRYQYRLSNYIAKNGSSRRICARLKICRNSQ DIIKAQLKKV.NSIG.FLRGL/KKVINRYQYRLSNYIAKNGSSRRICARLKICRNSQ DHIKAQLAKVNSIG.FLRGL/KKVINRYQYRLSNYIAKNGSSRRICARLKICRNSQ DHIKAQLAKVNSIG.FLRGL/KKVINNIDIFUVELSTDDPFTICGNLGICK.SLSMLELFQAFPQHHKQI DHIKAQLAKVNSIG.FLRGL/KKVINNIDIFUVELSTDDPFTICGNLGICK.SLSMLELFQAFPQHHKQI DEIKKKLARGCDKLP.VVKDL/KKVVNNIDIFUVELSTDDPFAICAKAL/K.FVCPPRKEINFIHDRAVNENEKM DEIKNNIMICNKAV.VLKSQ/KKFIQKHIHTLIDELMIDDGPNTICTKVHACK.SEPPIKEFIFIHDQAYS.KL DEIKNNIMICNKAV.VLKSQ/KKFIQKHIHTLIDELMIDDGPNTICTKVHACK.SEPPIKEFIFIHDQAYS.KL DEIKVQLSQV DQIG.FLKSICRGFVNKYMDVLIEELSTDDARTICGNISKYK.K. ETLKQKLISVCKVG.FLKSKK (GIMKKHLMVVIDELNTSDGWRAICVKIKACK, PKEVL.DLSY EEEKQLISYCKVG.FLKSKK (GIMKKHLMVVIDELNTSDGWRAICVKIKACK, PKEVL.DLSY EEEKQLISYCKVG.FLKSK/KGHWKKHLMVVIDELMTDDGPNTICTKIHKACK, PKEVL.DLSY EEEKQLISYCKVG.FLKSK/KKHLMVVIDELMTDDGPNTICTKIHKACK, PKEVL.DLSY EEEKQLISYCKVG.FLKSK/KKHLMVVIDELMTDDGPNTICTKIHKACK, PKEVL.DLSY EEEKQKLISYCKVG.FLKSK/KKHLMVVIDELMTDDGPNTICTKIHKACK, PKEVL.DLSY EEEKQKLISYCKVG.FLKSV/KYKLMVIVELSITDDFTICTNIKACK, PKEVL.DLSY EEEKQKLISYCKVG.FLKSV/KYKLMVIVELSITDDFTICTNIKACK, PKEVL.DLSY EEEKVKLMNCCKKV.MVX/MYDTUVEELSTDDARTICNIKYK, K. DDIKKKLMVDCHG.FLKSICRKVNKYHKYTDTUVEELSTDDARTICNIGVK.K. DDIKKKLMVCDEIG.FLKSICRKVNKYMSTLIEELSTDDARTICNIGVK.K. DDIKKKLMVCDEIG.FLKSICRKVNKYMSTLIEELSTDDARTICNIGVK.K. DDIKKKLAMVCDEID.SLKSLCRKVNKYMSTLIEELSTDDARTICNIGVK.K. DDIKKKLAMVCDEIG.FLKSLCRKVNKYMSTLIEELSTDDARTICNIGVK.K. DDIKKKLAMVCDEIG.FLKSLCRKVNKYMSTLIEELSTDDARTICNIGVK.K. DDIKKKLAMVCDEIG.FLKSLCRKVNKYMSTLIEELSTDDARTICNIGVK.K. DDIKKKLAMVCDEIG.FLKSLCRKVNKYMSTLIEELSTDDARTICNIGVK.K. DDIKKKLAMVCDEIG.FLKSLCRKVNKYMSTLIEELSTDDARTICNIGVK.K. DDIKKKLAMVCDEIG.FLKSKCRKVKHLGELIEELSTDDARTICNNGVGVC. ESKKSKLNVICNEIG.LLKSKCRFVKHHGELEELSTDDARTICNNGVGVC. ESKKSKLNVICNEIG.LLKSKCRFVKHGELEELSTDDARTICNNGVGVC.SKLLLFYPRNN.SDIKRALSVCDEIG.FLKKLKKLKKKHKKHLGELIEELSTDDARTICNNGVGVC. ESKKSKLSVCDGIG	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 119\\ 127\\ 129\\ 136\\ 141\\ 122\\ 129\\ 136\\ 141\\ 122\\ 121\\ 120\\ 112\\ 122\\ 126\\ 136\\ 147\\ 135\\ 121\\ 143\\ 147\\ 147\\ 147\\ 147\\ 147\\ 147\\ 147\\ 147$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-Nk-L2) 大黄鱼 Larimichthys crocea (LcNKL3) 私点叉尾鮰 Ictalurus punctatus (type1) 私点叉尾鮰 Ictalurus punctatus (type2) 私点叉尾鮰 Ictalurus punctatus (type3) 都马鱼 Danio rerio (nkla) 和马鱼 Danio rerio (nkla) 和马锥 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-2) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklc) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklc) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklc) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklc) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklc) 巴马拟coprinus carpio (Nkl1) 俚鱼 Cyprinus carpio (Nkl1) 俚鱼 Cyprinus carpio (Nkl3) 匹鱼 Cyprinus carpio (Nkl3) 匹鱼 Cyprinus carpio (Nkl4) 亚鱼 Cyprinus carpio (Nkl5) 匹鱼 Cynoglossus semilaevis 声鱼 Ctenopharyngodon idella 是半鱼 Oreochromis niloticus 大菱爭 Scophthalmus pecinirostris 国喜鲀 Sebastiscus marmoratus	ESVKEKIMRVENEIG. LLKSLCKKFVKGHLGELIEELTTSDDVRTICVNLKACK, PKELS ELDFESDEDAHTEMNDLLF AKIQELIAKA NGERPRFTRSIGEKUVRKYQKLINVIADKGTPESICIELSLCKSRGQ. ARIRCIAMGVONGERSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLRCRRVSQ. DIKAQLKKVENSIG. FLRGLCKININKYLDTUVEELSTDDPTTICGNLGICK, SLSMLELPQAFPOHHKQI. DIKKAQLAKVENSIG. FLRGLCKININKYLDTUVEELSTDDPTTICGNLGICK, SLSMLELPQAFPOHHKQI. DKIKAQLAKVENSIG. FLRGLCKININKYLDTUVEELSTDDPTTICGNLGICK, SLSMLELPQAFPOHHKQI. DKIKAQLAKVENSIG. FLRGLCKININKYLDTUVEELSTDDPTTICGNLGICK, SLSMLELPQAFPOHHKQI. DEIKNINATIC KAW. LLKGQ QKFVKTHLHTLIDELMINDGWNTICAKALVK, FCPPTKEENFTHDPAWENEKM. DEIKNINATIC KAW. UKSQCKFVCHULHTLIDELMINDGWNTICGKAK, SPEPTKEENFTHDPAWENEKM. DEIKNINATICNKAV. UKSQCKFVCHULHTLIDELMINDGWNTICGKIK, SEPPTKEENFTHDPAWENEKM. EETKQLSQV DGIG. FLKSLCRGFVNKYMDVLIEELSTDDPTTCSHLHVG. DEIKNINATICNKAV. UKSQCKFVCKHUMVUDELMISTDGWTTCSNIKAK, SEPPTKEFTFTHEQAYSKL. EETKQKLSVCDKG. FLKSKLGKMKHLWVIDELMISDGWTTCSNIKAK, PKEVL. DLSY EETKQKLSVCDKG. FLKSKLGKMKHLWVIDELMISDGWTTCSNIKAK, PKEVL. DLSY EETKQKLSVCDKG. ILKSLCKKVKHLWVVIDELMISDGWTTCINIKAK, PKEVL. DLSY EETKQKLSSVCDKG. ILKSLCKKVKHLWVIDELSTSDDVTTCINIKAK, PKEVL. DLSY DEIKTKINDTOKKG. PLKRQCKRFVEKYLHGVIDELMIDDGPNTCIKIHVK, EARTIKEFTVVHQAQFIANN. DDIKKLGSIDEGG. FLKSLCRKFVNKYTDTUVEELSTDDARTICNIKKY, KKL EDIKKKLEMV DEIG. FLKSLCRKVNKYTDTUVEELSTDDARTICNIKHVK, SAPPIKEFTLVHQAQHDNF. DDIKKLGSIDEGG. FLKSLCRKFVNKYTDTUVEELSTDDARTICNIKGK, K. DDIKKKLAMV DEIG. FLKSLCRKVNKYTMITUEELSTDDARTICNIGKK, K. DDIKKKLAMV DEIG. FLKSLCRKVNKYMKTILEELSTDDARTICNIKUK, SKPPIKEFTLAHDAHDNF. DDIKKKLAMV DEIG. FLKSLCRKVNKYMKTILEELSTDDARTICNIKUK, SKPPIKEFTLAHNSL. EETNQKLARTOQGG. FLKSLCRKVNKYMKTILEELSTDDARTICNINGUK, K. DDIKKKLAMV DEIG. FLKSLCRKVNKYMTTILEELSTDDARTICNINGUK, K. DDIKKKLAMV DEIG. FLKSLCRKVNKYMKTILEELSTDDARTICNINGUK, K. DDIKKKLAMV DEIG. FLKSLCRKVNKYMKTILEELSTDDARTICNINGUK, K. DDIKKKLAMV DEIG. FLKSLCRKVNKYMKTSLLEELSTDDARTICNINGUK, K. DDIKKKLAMV DEIG. FLKSKEHKVNKHMGELLEELSTDDARTICNINGUK, K. DEIKNKLANNTOREG. LLKSKCKHVCHKHGELSELSTDDARTICNINGUK, KNWSS DEIKNKLANNTOREG. FLKSKEHKVNKHHGELEELSTDDARTICNINGUK, SKELE.	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 127\\ 129\\ 136\\ 141\\ 122\\ 121\\ 122\\ 126\\ 141\\ 122\\ 126\\ 121\\ 122\\ 136\\ 147\\ 135\\ 121\\ 143\\ 147\\ 141\\ 150\\ 140\\ 140\\ 140\\ 140\\ 140\\ 140\\ 140\\ 14$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NkL2) 大黄鱼 Larimichthys crocea (LcNKL3) 粧点叉尾鮰 Ictalurus punctatus (type1) 斑点叉尾鮰 Ictalurus punctatus (type3) 斑马鱼 Danio rerio (nkla) 斑马鱼 Danio rerio (nkla) 斑马鱼 Danio rerio (nkla) 斑马鱼 Danio rerio (nkld) 大西洋鲑 Salmo salar (SsNK-lysin-1) 大西洋鲑 Salmo salar (SsNK-lysin-2) 大西洋鲑 Salmo salar (SsNK-lysin-3) 大西洋鲑 Salmo salar (SsNK-lysin-4) 马利以缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 의马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 입马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 四马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 四哥拉曼鱼 Cyprinus carpio (Nkl1) 俚鱼 Cyprinus carpio (Nkl1) 俚鱼 Cyprinus carpio (Nkl1) 俚鱼 Cyprinus carpio (Nkl1) 匹鱼 Cyprinus carpio (Nkl1) 匹曼 Cyprinus carpio (Nkl1) 匹爵 Cyprinus carpio (Nkl1) 匹爵 Cyprinus carpio (Nkl1) 匹爵 Cyprinus carpio (ESVNEKLMRVCNEIG, LLKSLCKKFVKGHLGELIELITSDDVRTICVNLKACK, PKELS., ELDFESDEDAHTEMNDLLF AKIQELAKACNGLRPFTRSICEKLURKYQDKLINVIADKGPPESICIRLSLKSRGQ ARIRCLMAGVCNGFRSRFVRSACKKVTRYQDKLINVIADKGPPESICIRLSLKSRGQ ARIRCLMAGVCNGFRSRFVRSACKKVTRYQDKLINVIADKGPPESICIRLSLKSRGQ DIIKAQLAKVCNSIG.FLRGLCKTINKYLDTIVEELSTTDDPTTICCNIGIC. EKIKKLKNCGDLP.VKDLCKMMNKNIDFLVEELSTTDDPTTICCNIGIC. EKIKKLKRGDLP.VKDLCKMMNKNIDFLVEELSTTDDPTTICCNIGIC. DEIKNILMICEKAW.LLKGQOKFVKTHLHTLIDELMINDGWNTICAKALVCK, FGPPRKEENFIHDRAVNENEKM. DEIKNILMICNAV.VLKSQCKKFICKHIHLIDELMINDGWNTICAKALVCK, FGPPRKEENFIHDRAVNENEKM. DEIKNILMICNAV.VLKSQCKKFICKHIHLIDELMINDGWNTICAKALVCK, SEPPIKEFFIFHERQAYS.KL. EEIKNQLAQVCDQIG.FLREICRWFVKKMDULIFELSTTDDARTICANISVCK,K. EEIKNQLAQVCDQIG.FLREICKWFVKKMDVLIEELSTDDARTICANISVCK,K. EEIKKKLISVCDKVG.FLKSLCRGFVNKYMDVLIEELSTDDARTICANISVCK,K. EEIKKKLISVCDKVG.FLKSLCRGFVNKYMDVLIEELSTDDARTICANISVCK,K. EEIKKKLISVCDKVG.FLKSLCRGFVNKYMDVLIEELSTDDARTICKNIKAK, PKEIL.DLSY. EEIKKKLISVCDKVG.FLKSLCRGFVNKYMDVLIEELSTDDARTICKNIKAK, KEVL.DLY. VEIKKKLISVCDKMG.LLKSLCKGMVKKHLWVLIEELSTDDARTICKNIKAK, KEVL.DLY. VEIKKKLISVCDKMG.LLKSLCKGMVKKHLWVLIEELSTDDDRYTCINIKACK, PKEIL.DLSY. DEIKTKINDICMKVG.FLKVQCKRFVEX/LHOVIDELMTDDGANTICIKNAK, KEVIL.DLSY. DEIKTKINDICMKVG.FLKVQCKRFVEX/LHOVIDELMTDDGANTICIKNAK, KEVIL.DLSY. DEIKTKINDICMKVG.FLKVQCKRFVEX/LHOVIDELMTDDGANTICIKNAK, KERTIVKDQA, DNF. DEIKTKINDICMKVG.FLKVQCKRFVEX/LHOVIDELMTDDGANTICIKNAK, KERTIVKDQA, DNF. DEIKTKINVCDEIG.FLKSLCRKFVNKYTDTIVEELSTDDARTICINIKGK, K. DDIKKGSIODEIG.FLKSLCRKFVNKYTDTIVEELSTDDARTICIKNIKK, KANVS DEIKNKLAMVCDEIG.FLKSLCRKFVNKYNDILEELSTDDARTICANIGVCK, K. DDIKKGLAMVCDEIG.FLKSLCRKFVNKYNDTIVEELSTTDDARTICANIGVCK, K. DDIKKGLAMVCDEIG.FLKSLCRKFVNKYNDTIVEELSTTDDARTICANIGVCK, K. DDIKKGLAMVCDEIG.FLKSLCRKFVNKYNDTIVEELSTTDDARTICANIGVCK, K. DDIKNKLGTVCDGIG.FLKSLCRKFVNKYNDTIVEELSTTDDARTICANIGVCK, K. DDIKNKLGTVCDGIG.FLKSLCRKFVNKYNDTIVEELSTTDDARTICANIGVCK, K. DDIKNKGNVCDEIG.LLKSLCRKFVNKYNDTIVEELSTTDDARTICANIGVCK, K. DDIKNKGNVCDEIG.LLKSLCRKFVNKYNDTIVEELSTTDDARTICANIGVCK, K. DDIKNKGNVCDEIG.LLKSLCRKFVKKHLEELLEELTTTDDVKTICANTA	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 9141\\ 144\\ 141\\ 127\\ 129\\ 129\\ 129\\ 129\\ 129\\ 121\\ 121\\ 122\\ 126\\ 121\\ 112\\ 122\\ 126\\ 121\\ 121$
大黄鱼 Larimichthys crocea (Lc-Nk-lysin) 大黄鱼 Larimichthys crocea (Lc-NkL2) 大黄鱼 Larimichthys crocea (LcNkL3) 延点叉尾鮰 Ictalurus punctatus (type1) 延点叉尾鮰 Ictalurus punctatus (type2) 延点叉尾鮰 Ictalurus punctatus (type3) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nkla) 延马鱼 Danio rerio (nkld) 大西洋鲑 Salmo salar (SNK-lysin-1) 大西洋鲑 Salmo salar (SNK-lysin-2) 大西洋鲑 Salmo salar (SNK-lysin-3) 大西洋鲑 Salmo salar (SNK-lysin-4) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNkla) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马拟缨鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马拟g鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马拟g鱼 Pseudocrossocheilus bamaensis (PbNklb) 巴马拟g鱼 Pseudocrossocheilus bamaensis (PbNklb) 王鱼 Cyprinus carpio (Nkl1) 厘鱼 Cyprinus carpio (Nkl1) 厘鱼 Cyprinus carpio (Nkl5) 厘鱼 Cyprinus carpio (Nkl5) 厘鱼 Cyprinus carpio (Nkl5) 厘鱼 Ciprinus carpio (Nkl6) 西头鲂 Megalobrama amblycephala (nkla) 司士勞 Paralichhys olivaceus 下聲 Paralichhys olivaceus 下聲 Paralichhys olivaceus 声聲 Dicentrarchus labrax	ESVKEKLMRVCNEIG, ILKSLCKKFVKGHLGELIEELTTSDDVRTTCVNLKACK, PKELS., ELDFESDEDAHTEMNDLLF AKIQELAKAONGLERFITESICEKLURKYQOKLINVIADKGTPESICIRLSLKSRGQ. ARIRCLMAGVONGGRSRFVRSACKKVTRRYQYRLSNYIAKNGSSRRICARLELCRRVSQ. DIKAQLKKVONSIG, FLRGLCKTINKYLDTLVEELSTDDPTTICWIGIC. EKIKGKLWONSIG, FLRGLCKTINKYLDTLVEELSTDDDTTICWIGIC. EKIKGKLWRGCDKLP, VVKDLCKKMVNKNIDFLVEELSTDDDTTICWIGIC. EKIKGKLKRGCDKLP, VVKDLCKKMVNKNIDFLVEELSTDDDTTICWIGICK, SLSNLEHPQAFPQHYQKL. DEIKNILMULEKAW, LLKGQCQKFVKTHLHTLIDELMNDGSWNTICAKAJUCK, SEPPIKESPIFHERAVNISNERM. DEIKNILMULCKAW, VLKSQCKFVCHHHTLIDELMNDGSWNTICKVHAK, SEPPIKESPIFHERQAYS, KL. EEIKNQLAQVODQIG, FLRSLCRGFVNKYMDULIEELSTDDGRTICKVHAK, SEPPIKESFIFHEQAYS, KL. EEIKNQLAQVODQIG, FLKSLCRGFVNKYMDULIEELSTDDRATICANISVK, K. ETIKQKLUSVOENG, FLKSLCRGFVNKYMDVLIELSTDDARTICANISVK, K. EEIKQKLUSVOENG, FLKSLCRGFVNKYMVUDELMTSDGWRICVKIKACK, PKEVL, DLSY. EEIKQKLLSVOENG, LLKSLCKGWKKHLWVUDELMTSDGWRICVKIKACK, PKEVL, DLSY. EEIKQKLLSVOENG, LLKSLCKGWKKHLWVUDELMTSDGWRICVKIKACK, PKEVL, DLSY. EEIKQKLLSVOENG, LLKSLCKGWKKHLWVUDELMTDDGPNTICTKIHACK, PKEVL, DLSY. EEIKQKLLSVOENG, LLKSLCKGWKKHLWUIDELMTDDGPNTICTKIHACK, PEPTIKEFTVVRDQAH, NNF. DEIKKILMNTOKKG, PLKNQCKRFVEKYLGVDELMTDDGPNTICTKIHACK, PEPTIKEFTVVRDQAFINENK. DDIKKKLGSICDEIG, FLKSLCRKFVNQYTDTUVEELSTTDDARTICUNISVCK, K. EDIKKKLGSICDEIG, FLKSLCRKFVNQYTDTUVEELSTTDDARTICUNISVCK, K. EDIKKKLGSICDEIG, FLKSLCRKFVNQYRDTUVEELSTTDDARTICUNISVCK, K. DDIKKKLGSICDEIG, FLKSLCRKFVNQYRDTUVEELSTTDDARTICUNISVCK, K. DDIKKKLGSICDEIG, FLKSLCRKFVNQYRDTUVEELSTTDDARTICUNISVCK, K. DDIKKKLGSICDEIG, FLKSLCRKFVNXYMGTLIEELSTTDDARTICUNISVCK, K. DDIKKKLGSICDEIG, FLKSLCRKFVNKYMGTLIEELSTTDDARTICUNISVCK, K. DDIKKKLSNVODKFK, PVSQCKKLVQKYLPNI IDELMTEDGPNITCTKIHVCK, SKPPIKEFILVHDQAH, DNF. DDIKKKLSNVODKG, FLKSLCRKFVNKYMGTLIEELSTTDDARTICUNISVCK, K. DEIKNKLGTTCDQIG, FLKSLCRKFVNKYMGTLIEELSTTDDARTICUNISVCK, K. DEIKNKLGTTCDQIG, FLKSLCRKFVNKYMGTLIEELSTTDDARTICUNISVCK, K. DEIKNKLGTVCDGIG, FLKSLCRKFVNKHLEELEELTTDDVRTICUNISQC, SEEL, LLFYAENGCGELIDVKELD, ESWKSKLINVONEIG, LLKSLCRKFVNSHMELVEELSTDDARTICUNISQC, SSVMLETTKAPFIKEDDFP ESKKSKLS	$\begin{array}{c} 147\\ 138\\ 144\\ 148\\ 129\\ 141\\ 144\\ 141\\ 127\\ 129\\ 129\\ 129\\ 129\\ 129\\ 129\\ 121\\ 121$
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图 2 鱼类 NK-lysin 多肽序列多重比对

Fig. 2 Multiple alignments of the NK-lysin polypeptide sequences of fish species

注:多肽序列引自相关研究论文,序列间完全保守的6个半胱氨酸残基通过阴影标出。

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图 3 硬骨鱼类 NK-lysin 系统发育分析 Fig. 3 Phylogenetic analysis of NK-lysin in teleosts 注: 数字表示置信度, 只显示置信度>50 的聚类结果。 研究论文 • <u>Iim</u> ARTICLE

基因的表达,但在皮肤、肠、胃及脑组织中 Lenkl3 基因的表达量较低(图 4)。

在受病原感染的大黄鱼4种组织中,Lcnkl3 基因 在不同组织中的表达趋势存在显著差异。在鳃组织 与头肾组织中,0h时Lcnkl3基因表达量最高,此后 总体呈现出持续下调的变化趋势(图5a、5b)。在脾脏 中,感染后72h内Lcnkl3基因的变化不显著(P>0.05), 到96h时则显著上调表达(P<0.05),在120h至168h 又恢复至基础表达水平(图5c)。在肝脏中,Lcnkl3基 因表达量在6h和24h时显著上调表达(P<0.05),在 48h和72h时的表达量又显著下调(P<0.05),96h时 恢复至基础表达水平,此后又于120h和168h时再 次上调表达(P<0.05)(图5d)。



图 4 未受病原感染的大黄鱼组织中 Lenkl3 基因的相对表达量





图 5 病原诱导过程大黄鱼鳃、头肾、脾脏、肝脏中 Lcnkl3 基因的相对表达量

Fig. 5 Relative expression profiles of *Lcnkl3* in thegill, head kidney, spleen, and liver of large yellow croaker during pathogen infection

注:显著差异表达(P<0.05)与极显著差异表达(P<0.01)分别以"*""**"表示。

2.3 Lenkl3 多肽片段的抗菌活性

经过色谱分离纯化及质谱鉴定, Lenkl3 多肽片段纯 度为 99.16%, 多肽的抗菌活性测定结果表明 Lenkl3 多肽 片段对金黄色葡萄球菌、哈维氏弧菌具有较强的抗菌活 性,其最小抑菌浓度及最小杀菌浓度均低于 1.5 μmol/L。 而浓度为 12 μmol/L 的多肽溶液能够有效抑制大肠杆菌 与副溶血弧菌的生长。但对于嗜水气单胞菌和美人鱼发 光杆菌, Lenkl3 多肽片段没有抑制效果(表 3)。

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Tuble Antibucterius activity of the Bennie polypeptide nuglicity								
	Lcnkl3 多肽片段抗菌活性							
头翋细困困怀 —	最小抑菌浓度(μmol·L ⁻¹)	最小杀菌浓度(µmol·L ⁻¹)						
金黄色葡萄球菌 Staphylococcus aureus	<1.5	<1.5						
大肠杆菌 Escherichia coli	3~6	6~12						
哈维氏弧菌 Vibrio harveyi	<1.5	<1.5						
副溶血弧菌 Vibrio Parahaemolyticus	3~6	6~12						
嗜水气单胞菌 Aeromonas hydrophila	>96	>96						
美人鱼发光杆菌 Photobacterium damselae	>96	>96						

表 3 Lenkl3 多肽片段的抗菌活性 Tab. 3 Antibacterial activity of the Lenkl3 polypeptide fragment

3 讨论

在前期的研究中,我们报道了 2 种类型的大黄 鱼NK-lvsin基因、即较为保守的Lc-nk-lvsin以及相对 不保守的 Lcnkl2, 在本研究中通过对大黄鱼 Lcnkl3 基因结构进行分析预测,我们发现 Lenkl3 的成熟肽 序列具有 NK-lysin 家族成员的主要特征, 即具有 Saposin B 结构域以及 6 个在不同序列间高度保守的 半胱氨酸残基,6个半胱氨酸残基可形成3个分子内 二硫键, 而 Saposin B 结构域可参与鞘脂降解, 这对 于 NK-lysin 发挥其抗病原活性至关重要^[37-38]。系统 进化分析结果显示 Lenkl3 与 Lenkl2 最先聚类并形成 独立的进化分支, 两者与包括 Lc-Nk-lysin 在内的其 他 NK-lysin 多肽序列相似性较低, 表明 Lcnkl3 与 Lcnkl2 均属于相对不保守的大黄鱼 NK-lysin 序列。 至今在大黄鱼组织中已鉴定出3种NK-lysin基因,其 他已被证实存在多个 NK-lysin 家族成员的鱼类有: 团头鲂(2 种)^[18],斑点叉尾鮰(3 种)^[14],斑马鱼(4 种)^[17],大西洋鲑(4 种)^[25],巴马拟缨鱼(5 种)^[28],鲤 鱼(6种)^[20],以上结果表明 NK-lysin 在硬骨鱼类中可 能出现了特异性分化。

荧光定量 PCR 测定结果显示 Lenkl3 基因在大黄 鱼不同组织以及受病原刺激不同阶段的表达量存在 显著差异。Le-nk-lysin 和 Lenkl2 主要在大黄鱼免疫 相关组织中表达,两者表达量最高的组织分别为鳃与 头肾,而 Lenkl3 在心脏中的表达量最高,这与在牙鲆 中发现的 NK-lysin 基因具有相似的表达模式^[15]。此外, Le-nk-lysin、Lenkl2 与 Lenkl3 在各组织及各诱导时间 点并未呈现出相似的表达调控规律,而是具有各不 相同的表达趋势,提示 3 种类型的 NK-lysin 基因均参 与了大黄鱼免疫应答,并且三者在大黄鱼免疫应答 过程中可能存在着功能分化。在其他硬骨鱼类中,不同类型的 NK-lysin 基因也具有不同的表达模式,例如在巴马拟缨鱼 5 种 NK-lysin 基因(PbNkla、PbNklb、PbNklc、PbNkld、PbNkle)中, PbNkla 在肠组织中高表达, PbNklc 在皮肤中高表达, PbNkld 在脑组织中高表达, PbNkle 在鳃、脾脏和头肾中表达量较高,而 PbNklb 在未感染的鱼体内不表达,仅在受嗜水气单胞菌诱导后表达^[28]。

多肽片段的抗菌活性测定结果表明 Lenkl3 的活 性与 Lenkl2 较为相似, 两者整体上优于 Lc-Nk-lysin 的 2 种多肽片段^[33-34]。Lenkl3 与 Lenkl2 均能有效抑 制和杀灭金黄色葡萄球菌和哈维氏弧菌、但抑制嗜 水气单胞菌和美人鱼发光杆菌的能力较弱。相较于 Lenkl2 多肽片段, 更低浓度的 Lenkl3 多肽溶液即可 有效抑制并杀灭大肠杆菌, 而 Lenkl3 多肽溶液对副 溶血弧菌的最小杀菌浓度则要高于 Lenkl2。相关研 究表明 NK-lysin 的抗菌活性与肽段的氨基酸组成及 其二级结构密切相关, 例如源自哺乳动物的 P-NK-2 对于革兰氏阳性菌的致死浓度远低于源自牙鲆的 JF-NK-2^[15]; 半滑舌鳎 NKLP27 能够通过破坏细胞膜 的完整性实现对革兰氏阳性菌和革兰氏阴性菌的杀 灭,然而由NKLP27末端截短5个氨基酸残基所生成 的衍生肽(NKLP22)则可能由于 α-螺旋结构的缩短而 导致其活性降低^[5]。目前有关鱼类 NK-lysin 对病原 菌作用构效关系的研究仍相对较少,因此需进一步 围绕大黄鱼 3 种 NK-lysin 的多肽结构及其抗菌能力 开展研究。

4 结论

对 Lcnkl3 序列结构的分析表明其与除 Lcnkl2 之外的鱼类 NK-lysin 基因存在较大差异,但仍属于大

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黄鱼 NK-lysin 基因家族。对 Lenkl3 基因表达特征及 Lenkl3 成熟肽片段抗菌活性的分析则提示 Lenkl3 可 能在大黄鱼对抗细菌感染的免疫应答过程中发挥了 免疫防御作用, 有必要围绕 Lenkl3 成熟肽抗菌活性 的构效关系开展深入研究。

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Molecular structure, expression characteristics, and antibacterial activity of polypeptide fragment of *Lcnkl3* in large yellow croaker

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Abstract: *NK-lysin* is an important immune gene involved in the non specific immune response against pathogen infection in teleosts. In previous studies, we found two types of *NK-lysin* genes in large yellow croaker (*Larimichthys crocea*), a commercially important fish. Herein, we report the gene sequence, expression characteristics, and antibacterial activity of the polypeptide fragment in the novel *NK-lysin* gene *Lcnkl3* of large yellow croaker. The open reading frame of *Lcnkl3* was 435 bp in length and coded 144 amino acid residues; it contained a Saposin B domain and six highly conserved cysteine residues in its polypeptide sequence (*Lcnkl3*). Phylogenetic analysis showed that *Lcnkl3* was most similar to *Lcnkl2* in large yellow croaker but was quite different from other teleost NK-lysin polypeptide sequences. The *Lcnkl3* gene exhibited different basic expression profiles in different tissues of uninfected large yellow croaker, and the expression was highest in the heart. The expression profiles of *Lcnkl3* differed in different tissues and at different infection stages during the pathogen-induced immune response. The polypeptide fragment derived from the mature *Lcnkl3* polypeptide sequence had different inhibitory and killing effects on different bacteria. These results indicate that *Lcnkl3* belongs to the *NK-lysin* gene family and plays a role in the immune response of large yellow croakers during pathogen infection.

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